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SYMPOSIUM ON THE COOPERATIVE STUDY OF THE KUROSHIO AND ADJACENT REGIONS (CSK)

Organized through the joint efforts of
UNESCO, FAO, and East-West Center

Honolulu, April 29 - May 2, 1968

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REPORT AND ABSTRACTS OF PAPERS

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
ROME, 1968

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Report of the Symposium on the Cooperative Study of the Kuroshio and Adjacent Regions (CSK)

Organized through the joint efforts of UNESCO,
FAO, and East-West Center
Honolulu, Hawaii, USA
29 April - 2 May 1968

REPORT AND ABSTRACTS OF PAPERS

Prepared by John C. Marr
as editor
in collaboration with the
Marine Biology and Environment Branch
Fishery Resources and Exploitation Division
FAO, ROME

and the

Office of Oceanography
UNESCO, PARIS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Rome, November 1968

EDITORIAL NOTE

This publication is part of the proceedings of the Symposium on the results of the Cooperative Study of the Kuroshio and Adjacent Regions (CSK) organised jointly by UNESCO and FAO with the support of the East-West Center, and held in Honolulu from 29 April to 2 May 1968 as a contribution to the cooperative study organised under the auspices of IOC. The present volume, issued by FAO, containing the general report and abstracts of papers presented at the Symposium was prepared and edited by John C. Marr, Area Director, Bureau of Commercial Fisheries, Honolulu, in collaboration with the Marine Biology and Environment Branch, Department of Fisheries, FAO, Rome and the Office of Oceanography, UNESCO, Paris. The full text of the contributed papers will be published in due course, together with an author index and subject index.

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GENERAL REPORT

1. INTRODUCTION

The Symposium was organized jointly by the Intergovernmental Oceanographic Commission of the United Nations Educational, Scientific and Cultural Organization (UNESCO), the Fishery Department, Food and Agriculture Organization of the United Nations (FAO), and the Office of Programs and Conferences, East-West Center of the University of Hawaii (EWC). It was held at the East-West Center, Honolulu, Hawaii, U.S.A. from 29 April to 2 May 1968. The contributions of the sponsoring organizations were:

UNESCO: Agreement with the EWC for holding the Symposium; travel expenses and subsistence of certain invited participants.

FAO: Travel expenses and subsistence of certain invited participants; publication of the volume containing the Report and the Abstracts of Papers.

EWC: Local arrangements including the provision of the meeting facility; travel expenses and subsistence of certain invited participants.

The Honolulu Laboratory, U.S. Bureau of Commercial Fisheries also assisted in making local arrangements and in providing document services.

2. BACKGROUND

The CSK was first proposed at the UNESCO Second Regional Meeting of Marine Sciences Experts in East and Southeast Asia held in Manila, 5-8 March 1962 and was recommended at the Intergovernmental Oceanographic Commission (IOC) Second Session held in Paris, 20-28 September 1962. Specific plans were developed at the UNESCO Meeting of Marine Sciences Experts on the Kuroshio Region held in Tokyo, 29-31 October 1963. The CSK was formally adopted at the IOC Third Session held in Paris, 10-19 June 1964. A CSK International Coordinating Group (ICG) was constituted, composed of National Coordinators and Assistant National Coordinators appointed by the participating countries. The ICG has met five times.

First Meeting	Manila	8-11 February 1965
Second Meeting	Paris	2 and 5 November 1965
Third Meeting	Tokyo	18-20 August 1966
Fourth Meeting	Bangkok	13-16 June 1967
Fifth Meeting	Honolulu	3-4 May 1968

An International Coordinator, Kiyoo Wadati, and an Assistant International Coordinator, John C. Marr, were chosen by the ICG at its First and Second Meetings, respectively. The countries initially participating in the CSK included China, Japan, Korea, Philippines, United Kingdom (Hong Kong), United States, U.S.S.R., and Viet Nam. They have subsequently been joined by Indonesia, Singapore, and Thailand.

The oceanographic aspects of the CSK include synoptic observations made in winter and summer, special studies in key areas, and observations made repetitively at selected reference stations. The fishery aspects of the CSK include studies of certain species selected on the basis of (1) the importance (weight, value, or both) of the fisheries based on them and (2) the fact that they are the basis of fisheries by two or more countries.

The Symposium, with John C. Marr as Convenor, was organized in five sections: The first was concerned with general reviews by countries, with Kiyoo Wadati as Chairman. The second was concerned with oceanography, with Kwan Ming Chan as Chairman. The third was concerned with plankton, with Tham Ah Kow as Chairman. The fourth was concerned with fishery, with Deb Menasveta as Chairman. The fifth and final section, with John C. Marr as Chairman, received the reports of the Chairmen of the sections on oceanography, plankton, and fishery.

3. REPORT OF OCEANOGRAPHY SECTION

A total of 21 papers on oceanography (physical oceanography and marine geology) was presented. Subject matters varied widely and some papers dealt with several topics; by category of topics the breakdown of the papers presented was:

Dynamics of the Kuroshio and related current	18
Distribution of oceanographic parameters	11
Bottom phenomena and marine geology	2

Out of 21 papers, 3 papers discussed the problem in general, while the majority of the papers, 18 in number, concentrated on description of specific material of the Pacific.

With regard to the origin of data, 14 papers were based upon the CSK data only and 5 upon non-CSK historical data, while 6 were on both.

Analysis of CSK data by several authors revealed the existence of an eastward movement of surface waters in the form, most likely, of a continuous belt between 20° and 25°N. A theoretical study of wind driven horizontal circulation had predicted the existence of such a current. It was suggested that this newly discovered current be called the "Subtropical Countercurrent." Details of the current were, however, not known at present. Therefore, it is considered that further elaborated studies were necessary, not only in the western Pacific but also in the other oceans.

The transport of the Kuroshio at various sections and the related currents such as the North Pacific Equatorial Current, the Mindanao Current, etc. were computed with the CSK data; the values were, however, not always compatible.

Comparing the Kuroshio with its homologue in the Atlantic Ocean, the Gulf Stream, the meandering of the Kuroshio south of Japan and existence of the Izu-Bonin Ridge were considered as characteristics of the Kuroshio. Detailed studies on the influence of the ridge on the southern route of the Kuroshio south of Japan might contribute effectively on the better understanding of the western boundary currents. Similarly, the possible importance of the Emperor Seamount Chain was noted. It was noted that within the area originally designated as the CSK area, some parts have not been covered by CSK cruises.

Therefore, the Symposium recommends the following investigations:

a. Investigation of the Subtropical Countercurrent.

b. Investigation of the Equatorial Current and the Kuroshio upstream of Japan (with emphasis on transport).

c. Investigation of the southern route of the Kuroshio and the influence of the Izu-Bonin Ridge and the Emperor Seamount Chain on the Kuroshio.

d. Investigation of the coastal and interisland shelf areas of the western Pacific and the South China Sea.

e. Investigation of the area south of 20°N in the CSK area.

The needs of coordinated efforts to study air-sea interaction and also inclusion of atmospheric studies in the CSK program were recognized. For this purpose the Symposium recommends the investigation of ocean-atmosphere interaction.

With regard to the methods and techniques for future studies, the conventional oceanographical observations for the Kuroshio would not afford any remarkable progress on the understandings of the Kuroshio. Fruitful results might be obtained using newly developed instruments. It was also noted that synoptic and synchronous observations undertaken as CSK projects had contributed greatly to the understanding of the Kuroshio and adjacent

regions, but in some areas no such observations have been carried out. In order to carry out observations with modern techniques and concepts, it is quite important to fix ship positions accurately, but adequate navigational aids are at present not available in the whole region, particularly in the southern part of the CSK area.

The Symposium recommends the following:

a. Undertake additional synoptic and synchronous observations in holiday areas, especially in the subtropical western Pacific.

b. Encourage use of new techniques such as STD, expendable BT, Swallow floats, and other methods of direct current measurement, methods of chemical analysis both improved and automatic, and airborne radiation thermometer.

c. Encourage improvements in navigational aids, including recommendation to make satellite navigation internationally available.

The compatibility of data obtained by an international cooperative study was considered essential. To achieve this goal, the Symposium recommends:

a. Undertake comparisons of methods of analysis.

b. Study the most effective way of quality control of data.

The importance of biological studies of the ocean should not be overlooked. In this connection the Symposium recommends that the study of biological effects such as nutrient cycles and primary productivity be emphasized.

It was the consensus that another symposium on CSK will be very desirable. For the success of such a symposium it might be desirable to consider recommending reports be presented on specific subjects in order to encourage study of these subjects, especially the comparison of methods and CSK reference stations. The representative of the Pacific Science Association, Dr. Miyake, Chairman of the Standing Committee on Marine Science, extended an invitation to hold a symposium at the forthcoming Pacific Science Congress in Australia in 1971.

The Symposium suggests that consideration be given to making a distinction between problems requiring international cooperation and other problems of more nearly national interest. Another distinction is between time dependent and nontime dependent phenomena.

4. REPORT OF PLANKTON SECTION

A total of 15 papers was read at the Symposium. They can be classified into the following categories:

Taxonomic papers
Distribution and environmental papers
Miscellaneous papers

4.1 Taxonomic Papers

Under this category there were two papers, viz: one on the euphausiids of Korean waters by Hong and one on ostracods from Taiwan Straits by Tseng.

4.2 Distribution and Environmental Papers

a. Regional distribution of major systematic groups of zoóplankton in Kuroshio region collected by Japanese ships 1965-66 by Yamazi.

b. Marine biology investigations of Kuroshio region by Kun.

c. Effect of environmental factors on macro-zooplankton around Taiwan by Yu and Lee.

d. Plankton in Singapore waters in relation to environment by Tham, Khoo, and Chua.

e. Zooplankton distribution and abundance in Lamon Bay (Philippines) by Magnusson, Tan, and Rizalina.

f. Chaetognaths in Korean waters by Park.

g. Chaetognaths around Taiwan by Liaw.

h. Copepods around Taiwan by Tan.

4.3 Miscellaneous Papers

a. Particulate organic matter in seas off Japan by Saijo.

b. Primary production in Kuroshio area by Saijo.

c. Plankton settling volumes around Taiwan 1965 by Tseng.

d. Biological structures in sea south of Japan by Motoda, Kawamura, and Ishii.

e. Preliminary report on zooplankton processing in Japanese CSK studies by Motoda, Irie, and Yamazi.

These papers form a useful contribution to the knowledge on plankton in the region and the data presented were discussed at some length by those present, although it was felt that more planktologists, especially those who presented papers, should have been present.

It is significant that the majority of the papers dealt with the distribution of plankton organisms in relation to the environment.

It was generally felt that the plankton data collected would be more meaningful if they could be presented in a form similar to that given in Yamazi's paper.

The Plankton Group submits the following recommendations for consideration:

a. In order to get a clearer picture of distribution of planktonic organisms in space and time, future work should be centered around the interrelationships between the planktonic organisms and the environment.

b. A second CSK symposium would be most useful but in organizing for such a symposium, steps should be taken to ensure that sufficient planktologists, in particular those who are presenting papers, would be present to make discussion fruitful. In such a second symposium, it is proposed that taxonomic papers will be mentioned by title only unless the author is present.

c. In order that the plankton data collected would be more meaningful, it is recommended that the International Coordinator for CSK should find ways and means to publish the data in a form similar to that given in Yamazi's paper.

5. REPORT OF FISHERY SECTION

A total of 29 fishery papers was presented during the 2-day Symposium. Subject matter varied widely and each of the eight species or group of species selected for intensive study by CSK participants was represented by at least one paper. By category the breakdown of the papers presented was:

Fishery-oceanography	3	Scomberomorus spp.	1
Biological (general)	3	Rastrelliger spp.	3
Bottom trawl (general)	4	Pseudosciaena manchurica	1
Stolephorus spp.	3	Saurida spp.	2
Cololabis saira	1	Nemipterus spp.	3
Katsuwonus pelamis	4	Others	1

General emphasis of the Symposium was on bottom trawl fishing, principally because of the importance of this type of fishing in the western Pacific, especially in Southeast Asia. Also, several of the bottom dwelling fish species usually taken by bottom trawl gear are included in the list of selected species. These are Saurida spp., Nemipterus spp., and Pseudosciaena manchurica.

5.1 Taxonomy

It became evident in the early stages of the CSK program that difficulty would be encountered in the identification of certain groups of fishes. The Coordination Group of the CSK program in response to these problems has already requested Mr. T. Matsui of the Scripps Institution of Oceanography, University of California, to act as a referee for Rastrelliger spp., Mr. W. Chan of Hong Kong Agriculture and Fisheries Department as referee for Scomberomorus spp., and Mr. I. Ronquillo, Department of Agriculture and Natural Resources, Philippine Fisheries Commission, as referee for Stolephorus spp. in collaboration with Dr. Tham Ah Kow of the University of Singapore.

The participants of the Fishery Section of the Symposium (referred to hereafter as the Group) felt, however, that Nemipterus spp. and Saurida spp. also needed clarification and recommends selection of referees for these two groups. The Group recommended that the Assistant International Coordinator for Fisheries approach Dr. S. Shindo of Seikai Regional Fisheries Research Laboratory to act as a referee for Saurida spp. and Dr. D. Eggleston of the Hong Kong Agriculture and Fisheries Department as referee for Nemipterus spp.; the latter to work in close collaboration with Dr. G. Kühlmorgen-Hille of the Marine Fisheries Laboratory, Bangkok, Thailand, and Dr. F. Talbot of the Australian Museum.

In resolving taxonomic problems, the referees will need access to specimens from various areas. In this connection there are two possible approaches. The first is for participating countries to collect and ship specimens to referees for identification. Another is to obtain funds to provide for travel and other expenses to permit referees to visit the various countries in order to collect the needed specimens. The Group felt that both approaches should be pursued.

The following specific recommendations made by the Group on taxonomic problems are:

a. Request Mr. I. Ronquillo to advise the Coordination Group of the basis on which he decided to consider Stolephorus pseudoheterolobus as a synonym of S. heterolobus.

b. Determine the distribution of Rastrelliger faughni.

c. Encourage countries to provide specimens of commercially important species to Mr. W. Chan of the Hong Kong Agriculture and Fisheries Department, in order that he may complete the fish cards requested by the Indo-Pacific Fisheries Council.

d. Add Decapterus spp. and the family Sciaenidae to the existing selected list of CSK species.

5.2 Stock Identification

The Group was of the opinion that stock identification is essential in studies leading to the rational exploitation of fishery resources. It therefore recommends identification of the stocks of the various selected species be made by participating countries which exploit these species. This identification could be accomplished by the study of subpopulations using serological and immunogenetic methods and by tagging, accompanied by analyses of catch and effort data and the distribution of eggs and juvenile fish.

The following specific recommendations made by the Group on stock identification problems are:

a. Clarify the population structure of Rastrelliger brachysoma in the Gulf of Thailand and adjacent waters.

b. Clarify the population structure of Cololabis saira in the Sea of Japan and the western North Pacific. The methods of tagging and subpopulation studies by serological and immunogenetic techniques should be continued and encouraged for this species.

c. Continue the study of the relationship of skipjack tuna in the southwest Pacific Ocean and other areas of the Pacific by means of tagging and serological and immunogenetic techniques.

5.3 Stock Assessment

The Group agreed that in the evaluation leading to the rational exploitation of fishery resources, participating countries should examine carefully the catch and effort data already collected and that, if these data have not yet been compiled, the collection of proper catch and effort data should be initiated without delay.

The following specific recommendations made by the Group on stock assessment problems are:

a. Conduct stock assessment studies of the more important species taken by the trawl fisheries in the CSK area.

b. Continue studies of age and growth of Rastrelliger brachysoma by the method of size-frequency analyses. This study should be accompanied by an experimentally-designed tagging program to collect independent age and growth data, for comparative purposes.

c. Participating countries should be encouraged to commence stock assessment studies of the commercially important species. Exchange of data and other pertinent information among CSK participants should be encouraged, particularly through the FAO Fishery Data Center as agreed upon by the CSK International Coordination Group at the Third Meeting.

5.4 Exploratory Fishing Survey

With respect to ground fish resources of the Sunda Shelf, the Group agreed that due to the lack of sufficient data from previous trawling surveys in the central part of the Sunda Shelf, in the waters around Anambas and Natuna Islands and in the waters off North Borneo and Sarawak coasts, trawling surveys through the mutual effort of participating countries in the region should be repeated in these waters. Consideration should be made of time and space factors in order to obtain sufficient data to reach definite conclusions as to the status of the demersal resources in these waters. The Group also recommends the initiation of trawl fishing surveys in the Java Sea.

In connection with the trawl fishing surveys in the South China Sea, the Group recommended that plankton and other environmental studies be carried out.

As for the study of the skipjack resources in the western Pacific, the Group recommends exploratory fishing using various types of fishing gear be initiated.

As for the study of the saury resources, the Group recommends conducting exploratory fishing using stick-held net with night lamp and gill nets in the western and central Pacific of the CSK area.

5.5 Intercalibration of the Fishing Gear

The Group repeated the recommendation made at the Fourth Meeting of the Coordination Group in Bangkok in 1967; that, when possible, an intercalibration of trawlers and trawl gear be made in order to arrive at conversion factors which can be used in the development of standardized catch rates.

The Group recommended that this intercalibration should initially involve research trawlers of participating countries, and could most suitably be conducted in connection with the exploratory fishing survey programmed for the South China Sea.

5.6 Environmental Studies

Several papers contributed by Japan and Korea have demonstrated the effects of currents, eddies, oceanic fronts, etc. of the Kuroshio and associated currents on the transport of fish eggs and larvae of saury, mackerel, hairtail, etc. and on the fluctuation of the stock sizes of these fish. The Group was of the opinion that this type of study should be continued and invited participating countries to initiate such a program of study, when possible.

In order to prevent marine pollution (including oil pollution) and to improve the marine environment, mixing, diffusion and transport through the Kuroshio and other associated current systems should be carefully studied.

In future studies, tagging should be used to supplement the knowledge of the movement of certain stocks of fish along and within the Kuroshio Current.

5.7 Mariculture

The Group was of the opinion that participating countries interested in the culture of marine fishes, including tunas, should be encouraged to carry out these studies.

5.8 Publication of Naga Expedition Reports

The Group was informed that between October 1959 and December 1960, Thailand, Viet Nam, and the United States of America carried out an oceanographic expedition (Naga Expedition) which included fisheries resources surveys in the Gulf of Thailand and the South China Sea.

Results of this expedition have been published in part in a restricted form, e.g., handbooks or circular reports. These reports have been sent to selected institutions and are not available for general distribution. Considering the general lack of information of the biota and environment of the South China Sea and recognizing the great contribution the publication of the Naga Expedition could give towards the planning of future surveys of the South China Sea, the Group strongly recommends effort be made to publish the results of the Naga Expedition.

5.9 Intensification of the CSK Program in the South China Sea

The Group recommends strongly that the survey of the CSK program in the South China Sea be intensified.

6. RECOMMENDATIONS

The recommendations arising from the CSK Symposium were presented to the ICG/CSK Fifth Meeting. The final set of recommendations adopted at the Fifth Meeting includes those from the Symposium as well as some arising during the course of the Fifth Meeting, as follows:

6.1 Bathymetric Studies

No. 1 The International Coordination Group for CSK requests the International Coordinator to maintain close contact with the Hydrographic Department of the Maritime Safety Agency, Japan to obtain information on specific areas and/or tracks to which sounding data are desired, and requests further such information be publicized by the CSK Newsletter.

The Group recommends that CSK participating Member States pay due consideration to traversing such areas during appropriate CSK cruises as far as possible.

6.2 Standard Oceanographic Equipment

No. 2 With reference to Resolution V-21 of the Fifth Meeting of IOC, the Group recommends that UNESCO assist in the provision of standard oceanographic equipment (e.g., salinometer, plankton net, bathythermographs, etc.).

6.3 Oceanography

No. 3 The Group recommends the following investigations:

a. Investigation of the Subtropical Countercurrent.

b. Investigation of the Equatorial Current and the Kuroshio upstream of Japan (with emphasis on transport).

c. Investigation of the southern route of the Kuroshio and influence of the Izu-Bonin Ridge and the Emperor Seamount Chain on the Kuroshio.

d. Investigation of the coastal and interisland shelf areas of the western Pacific and South China Sea.

e. Investigation of the area south of 20°N in the CSK area.

No. 4 The needs of coordinated efforts to study air-sea interaction and also inclusion of atmospheric studies in the CSK program were recognized. For this purpose, the Group recommends the investigation of ocean-atmosphere interactions.

No. 5 With regard to methods and techniques of future studies, the Group recommends:

a. Undertake additional synoptic and synchronous observations in holiday areas, especially in the subtropical western Pacific.

b. Encourage use of new techniques such as STD, expendable BT, Swallow floats, and other methods of direct current measurement, methods of chemical analysis both improved and automatic, and airborne radiation thermometer.

c. Encourage improvements in navigational aids, including recommendation to make satellite navigation internationally available.

No. 6 The compatibility of data obtained by an international cooperative study was considered essential. To achieve this goal, the Group recommends:

a. Undertake comparisons of methods of analysis.

b. Study the most effective way of quality control of data.

No. 7 The importance of biological studies of the ocean should not be overlooked. In this connection the Group recommends that the study of biological effects such as nutrient cycles and primary productivity be emphasized.

6.4 Plankton

No. 8 In order to get a clearer picture of distribution of planktonic organisms in space and time, the Group recommends future work should be centered around the interrelationships between the planktonic organisms and the environment.

No. 9 A second CSK symposium would be most useful but in organizing for such a symposium, the Group recommends steps should be taken to ensure that sufficient planktologists, in particular those who are presenting papers, would be present to make discussion fruitful. In such a second symposium, it is proposed that taxonomic papers will be mentioned by title only unless the author is present.

No. 10 In order that the plankton data collected would be more meaningful, the Group recommends that the International Coordinator for CSK should find ways and means to publish the data in a form similar to that given in Yamazi's paper.

6.5 Fisheries

No. 11 Concerning taxonomic problems, the Group recommends:

a. Request Mr. I. Ronquillo to advise the Coordination Group of the basis on which he decided to consider Stolephorus pseudoheterolobus as a synonym of S. heterolobus.

b. Determine the distribution of Rastrelliger faughni.

c. Encourage countries to provide specimens of commercially important species to Mr. W. Chan of Hong Kong, in order that he may complete the fish cards requested by the Indo-Pacific Fisheries Council.

d. Add Decapterus spp. and the family Sciaenidae to the existing selected list of CSK species.

No. 12 Concerning stock identification problems, the Group recommends:

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b. Clarify the population structure of Cololabis saira in the Sea of Japan and the western North Pacific. The methods of tagging and subpopulation studies by serological and immunogenetic techniques should be continued and encouraged for this species.

c. Continue the study of the relationship of skipjack tuna in the western Pacific Ocean and other areas of the Pacific by means of tagging and serological and immunogenetic techniques.

No. 13 Concerning stock assessment problems, the Group recommends:

a. Conduct stock assessment studies of the more important species taken by the trawl fisheries in the CSK area.

b. Continue studies of age and growth of Rastrelliger brachysoma by the method of size-frequency analyses. This study should be accompanied by an experimentally-designed tagging program to collect independent age and growth data for comparative purposes.

c. Participating countries should be encouraged to commence stock assessment studies of the commercially important species. Exchange of data and other pertinent information among CSK participants should be encouraged, particularly through the FAO Fishery Data Center as agreed upon by the CSK International Coordination Group at the Third Meeting.

No. 14 With respect to ground fish resources of the Sunda Shelf, the Group recommends that due to lack of sufficient data from previous trawling surveys in the central part of the Sunda Shelf, in the waters around Anambas and Natuna Islands and in the waters off North Borneo and Sarawak coasts, trawling surveys through the mutual effort of participating countries in the region should be repeated in these waters. Consideration should be made of time and space factors in order to obtain sufficient data to reach definite conclusions as to the status of the demersal resources in these waters. The Group also recommends the initiation of trawl surveys in the Java Sea. In connection with the trawl fishing surveys in the South China Sea, the Group recommends that plankton and other environmental studies be carried out.

No. 15 As for the study of the skipjack resources in the western Pacific, the Group recommends exploratory fishing using various types of fishing gear be initiated.

No. 16 As for the study of the saury resources, the Group recommends conducting exploratory fishing using stick-held net with night lamp and gill nets in the western and central Pacific of the CSK area.

No. 17 The Group repeats the recommendation made at the Fourth Meeting of the Coordination Group in Bangkok in 1967; that, when possible, an intercalibration of trawlers and trawl gear be made in order to arrive at conversion factors which can be used in the development of standardized catch rates.

The Group recommends that this intercalibration should initially involve research trawlers of participating countries, and could most suitably be conducted in connection with the exploratory fishing survey programmed for the South China Sea.

No. 18 The Group was informed that between October 1959 and December 1960, Thailand, Viet Nam, and the United States of America carried out an oceanographic expedition (Naga Expedition) which included fisheries resources surveys in the Gulf of Thailand and the South China Sea. Results of this expedition have been published in part in a restricted form, e.g., handbooks or circular reports. These reports have been sent to selected institutions and are not available for general distribution. Considering the general lack of information of the biota and environment of the South China Sea and recognizing the great contribution the publication of the Naga Expedition could give towards the planning of future surveys of the South China Sea, the Group strongly recommends effort be made to publish the results of the Naga Expedition.

6.6 South China Sea Program

No. 19 The Group recommends strongly that the survey of the CSK program in the South China Sea be intensified.

6.7 Publication of Results of CSK Symposium

No. 20 With regard to the publication of the results of CSK Symposium, the Group recommends:

a. There be two publications arising from the CSK Symposium:

(1) The Report which would include (1) a Summary Report covering the highlights of scientific results and the recommendations, and (2) the abstracts of the submitted papers.

(2) The Proceedings which would include the submitted papers.

b. The Report be published in the immediate future by FAO and UNESCO.

c. The Proceedings be published as soon as possible, perhaps by the East-West Center Press if this can be arranged.

d. All submitted papers be accepted for publication except those which have already been published elsewhere in English and those which do not meet the generally accepted standards for scientific papers.

e. The Convenor of the Symposium, John C. Marr, be asked to serve as editor of the Report and the Proceedings.

6.8 Regional Equipment Pool

No. 21 With reference to recommendation No. 3 of the Fourth Meeting of Marine Science Experts in Southeast Asia, the Group recommends that UNESCO initiate the setting up of a Regional Equipment Pool for the promotion of more efficient distribution and maintenance of equipment.

6.9 Synoptic Surveys

No. 22 The Group recognized the importance and the necessity of continuing the CSK at this stage. The Group agreed to terminate the cooperative synoptic surveys in the Pacific area after the summer cruises in 1970. The emphasis then should be put on synoptic surveys in subtropical and tropical areas in the western Pacific, where observations were rather scarce, and on stations occupied for long periods at selected points of the region.

The situation with regard to cooperative synoptic surveys in the South China Sea is different from that in the Pacific area, since the former began later than the latter.

At the present moment, it would appear that the cooperative synoptic surveys in the South China Sea and adjacent waters will extend beyond summer 1970. The Group recommends that the International Coordinator in cooperation with Dr. Deb Menasveta be requested to coordinate with the countries concerned in this survey to produce a basic plan and timetable for this survey and to circulate to National Coordinators not later than 3 months in advance of the next ICG/CSK meeting.

The Group recommends that another symposium be held in the first half of 1970 in order to review the scientific achievements of CSK and to advise ICG/CSK on the future of CSK.

6.10 Joint IPFC-CSK Meeting

No. 23 Noting that the 13th Session of the Indo-Pacific Fisheries Council will be in Australia in October 1968, the Group recommends that a joint IPFC-CSK meeting be made a part of that session.

6.11 KDC Atlases

No. 24 The Group recommends that before the KDC Atlases are bound, unbound copies be circulated to ICG/CSK. When approvals have been received from the National Coordinators, the cover will be added, without the word "Provisional," i.e., this will be the final form of the Atlas.

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9. ABSTRACTS OF PAPERS

No. 1 Distribution of Biochemical Elements in the Kuroshio Area of Japan

by

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Dissolved oxygen, phosphate phosphorus, silicate silicon, and pH in sea water south and east of Japan have been observed since 1953. Those data obtained in the observations of Japan Meteorological Agency from 1956 to 1965 were classified by summer and winter and statistically treated. Annual mean values and standard deviations of those elements for 10 years were calculated in every degree of latitude and longitude to see the general features of distributions.

These results may serve for a standard in consideration of changes in oceanographic conditions and in estimation of biological activity in each year.

Recently inorganic nitrogen compounds (NH_3, NO_2, NO_3), organic phosphorus, and alkalinity have been determined, but data are not ample enough to consider general distributions.

In deep waters below the layer of oxygen minimum, distributions of biochemical elements may be useful to trace the transport or circulation of deep ocean water.

No. 2 The Partial Pressure of Carbon Dioxide in the Air and in the Sea of the Northwestern Pacific Ocean

by

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During a cruise of R/V Fuji for the 7th Japanese Antarctic Research Expedition in 1965-66 and of R/V Ryōfu Maru for the CSK in 1967, the partial pressure of carbon dioxide (pCO_2) in the air and in sea water was measured, mainly by infrared absorption analysis (Beckman-Tōshiba Infrared Analyser I. R. -315) but partly by pH and alkalinity measurements.

The pCO_2 in the air over the northwestern Pacific Ocean is about 320 ppm and changes little from place to place, whereas slightly higher values--as much as 330 ppm--are observed in the coastal area south of Japan. On the other hand, the pCO_2 in surface water changes locally over the wider range of 250-400 ppm, presumably because of solar radiation and biological photosynthetic processes.

As a whole air-sea equilibrium is not attained, largely because of the restricted rate in the transfer of carbon dioxide across the sea surface.

In the open ocean the pCO_2 in the air is higher by 20-70 ppm than that in surface water. On the contrary, in the coastal water north of the Luzon Island the pCO_2 in the air is lower than that in surface water.

No. 3 The Kuroshio-Oyashio Front: a System of Near-Stationary Vortices

by

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The author's kinematic model of the Kuroshio-Oyashio front, consisting of a pair of von Kármán vortex streets arranged side by side (or four parallel rows of Rankine vortices), accounted for many major features of that important region of the Pacific Ocean. However, the model did not include coriolis force; as a result, the model predicts an eastward displacement of the vortex system of about 50 cm sec^{-1}, whereas observations suggest that the vortices are more or less stationary. Recent theoretical work by Warren shows that, on a beta plane, circular currents of the type proposed in the vortex street model should be displaced westward at a rate which would, in large part, cancel the eastward velocity induced by other nearby vortices in the author's model without the beta plane effect. Taken together, these two theoretical analyses complement each other, providing a model which is complete and accounts for all major observed features of the Kuroshio-Oyashio front, at least to the degree which can be expected from first-order theory applied to the existing fund of published data. Some predictions based on the model are presented as a basis for field work designed to test the validity of the theoretical model.

No. 4 Characteristics of Waters East of Mindanao, Philippine Islands, August 1965 *

by

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Observations from two hydrographic sections made in August 1965 extending from Mindanao easterly to 130°E show characteristics of the Mindanao Current and surrounding waters. The offshore limit of continuous strong currents is 70-80 km. Geostrophic surface currents and and the ship's set are consistent near Mindanao. The transport and the depth of the current are different on the two sections, which are only about 100 miles apart.

A double salinity maximum is observed within the thermocline at the eastern end of the southern section. This feature has been attributed to overlapping of waters of North and South Pacific origins because of seasonal changes in circulation. In the present study the deeper maximum is observed at a thermosteric anomaly near 220 cl/t and is associated with a thermostad near 15°C.

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* Contribution 120 of Chesapeake Bay Institute and Department of Oceanography, The Johns Hopkins University, and Contribution 2103 of Woods Hole Oceanographic Institution.

No. 5 The Seasonal Variation of Hydrological Properties of the Northern Portion of the South China Sea

by

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Temperature, salinity, and dissolved oxygen data were collected in the South China Sea along four section lines between Hong Kong - Taiwan - Luzon - Gulf of Tonkin - Hong Kong during 1961-66 by F.R.S. Cape St. Mary. From these observations the characteristic features of each section in different monsoon seasons are described. The major water masses in the area under survey are (1) the Subtropical Lower Water with its salinity maximum ca. 34.7°/$_{oo}$ at 75-250 m, (2) the Northern Intermediate Water with its salinity minimum ca. 34.4°/$_{oo}$ at 400-600 m, (3) the fresh water discharge from the Pearl River, and (4) the Northern China Coastal Water flowing along the western Taiwan Strait. The water in the shelf area is a mixed water mass of the above waters, and its hydrological properties vary in different monsoon seasons.

The river dilution, the inflow of Pacific Ocean water, and the monsoon current transport are the major factors which affect the seasonal fluctuations of the hydrographic conditions in the northern portion of the South China Sea. A general discussion of the above factors and the water flow pattern based on current measurements with an Ekman-merz meter are presented.

No. 6 Preliminary Tagging Studies of Demersal Fish in the Gulf of Thailand

by

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Because of rapid expansion of trawl fisheries in the Gulf of Thailand, knowledge of the life history of certain commercially important species of demersal fish is urgently needed for conservation of these fishery resources in the future. The quickest way to obtain information on the distribution and dispersion of the stocks of these species is by means of tagging. A tagging program of demersal fish in the Gulf of Thailand was initiated in March 1966 by the Demersal Fish Research Unit of the Department of Fisheries of Thailand. Two kinds of tags were used; dart tags and plastic tape tags. Eight species of demersal fish were tagged and released in the Gulf of Thailand; these were Priacanthus tayenus, Scolopsis cancellatus, Nemipterus hexodon, N. japonicus, N. furcosus, N. tolu, N. marginatus, and Lutianus malabaricus. So far, the return rate of tagged fish has been disappointing. Less than 1% of some species tagged were recovered. Thus, this report is preliminary in nature and presents only certain aspects of the biology of P. tayenus, which had the highest percentage of returns. Growth and estimate of extreme length ($L\infty$) of this species were determined. The general pattern of movement of the demersal fish in the Gulf of Thailand, so far, seems to be of the "Disperse" type. A correlation between percentage of returns and swimming behavior noted at release is established. In addition, a brief account of the demersal fish tagging operation carried out along with the Thai-Malaysian joint trawling survey off the east coast of Malay Peninsula in March 1967 is presented.

No. 7 A Summary Report on Yellow Croaker in Korea

by

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The yellow croaker, Pseudosciaena manchurica, is the basis of an important fishery in Korea. The catch, made by drift gill net, stow net, and trawl, was about 45,000 M/T in 1966. Over half the catch is made in April-June, a period which coincides roughly with the spawning season. A small-scale tagging experiment was carried out in 1967, but there have been no recoveries. Length-frequency distributions are given for the years 1962-66. The von Bertalanffy growth equation was fitted to age-length data.

No. 8 On the Variation of Velocity and Volume Transport of the Kuroshio Current

by

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From the year 1965 to 1967, four cruises of CSK were carried out by the R/V Yang Ming in the waters surrounding Taiwan. In each of these cruises, three sections of observations were made in the sea area east of Taiwan. They are parallel to lines of latitude and approximately perpendicular to the flow of the Kuroshio. Relative currents on the surface and at different depths were computed from the hydrographic data with dynamic equations. The results show that the current intensifies between stations toward the coast of Taiwan and it is relatively steady in different seasons and from year to year. On the other side of the current, between stations toward the open ocean, the velocity and transport are low and changeable; sometimes the current becomes a counter-flow. The counter-flow is due to eddy formation and is subject to great seasonal variations. Direct measurements with GEK (Geomagnetic Electrokinetograph) current meter were made in the summer of 1967; the readings are in agreement with the calculated values.

No. 9 Biology of Nemipterus virgatus in the Northern Part of the South China Sea

by

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Nemipterus virgatus is most abundant in the northern part of the South China Sea and the southern part of the East China Sea. In the South China Sea the spawning season is short (February-May). The main spawning ground is 60-100 miles southwest of Hong Kong.

N. virgatus eats motile benthic organisms, mostly crustacea.

Males grow quicker and larger than females. Maximum size L.C.F. male 37 cm; female 29 cm. Otoliths can be used for age determination; maximum age is 6 years. Most landed fish are 1 or 2 years old.

No. 10 Nemipterus of the CSK Region: Preliminary Notes

by

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Color descriptions and notes on the commercial importance of Nemipterus spp. in the CSK area are presented.

No. 11 Skipjack Tuna Subpopulation Identified by Genetic Characteristics in the Western Pacific

by

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As a part of the Pacific-wide studies of the population structure of the skipjack tuna (Katsuwonus pelamis), more than 2,500 blood specimens have been collected from areas off the northeastern coast of Japan, Okinawa, and the Mariana and Palau Islands in the western Pacific Ocean. Genetic compositions of the blood group and serum group systems for the specimens were compared between different areas. The results indicated that 1) no significant heterogeneity was seen in all the genetic systems used within the western Pacific, and 2) gene frequencies of the serum esterase system of the samples from the western Pacific are significantly different from those of the central Pacific (Hawaii and Line Islands) and the eastern Pacific (Baja California). On the basis of these observations as well as other available biological information, the skipjack tuna population structure in the western Pacific is discussed.

No. 12 Bathymetry of the South China Sea

by

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The South China Sea can be divided into five bathymetric provinces: the shelf areas; the submerged continental margin of Asia; the submerged island margins of Taiwan, Luzon, Palawan, and Borneo; the plateau of the "Dangerous Grounds" area; and the central basin. The shelf areas are broad on the west and south, and narrow along the islands on the east. Coral reefs are common on nearly all shelves. Water exchanges take place across the shelves with the Indian Ocean and the East China Sea at sill depths of 30 and 70 m respectively (17 and 38 fathoms). Channels through the shelves connect the South China Sea with the Sulu Sea and Pacific Ocean at depths of 450 and 100 m respectively (246 and 55 fathoms). The submerged continental and island margins include a number of terraces, coral reefs, and valleys. The coral reefs occur primarily on the terraces. Since the terraces extend to depths of 1,800 m (1,000 fathoms), the presence of coral reefs upon them is unusual. It is thought that the terraces represent subsiding blocks, and the coral growth has kept pace with the subsidence. The "Dangerous Grounds" area includes a large plateau upon which

numerous coral reefs have developed, and into which a number of valleys have been cut. Since the irregular plateau surface lays at depths between 1,500 and 2,000 m (800 and 1,100 fathoms) the presence of coral reefs indicates subsidence of this block also. The central basin is primarily a plain which slopes generally southward from 3,400 to 4,200 m depth (1,850 to 2,300 fathoms). A number of seamounts are present near the center of the basin. These are thought to be volcanic in origin, and most do not reach sea level. The bathymetry of the South China Sea is portrayed on a bathymetric features chart, a recent development at the Naval Oceanographic Office. This chart shows features and provinces in outline form rather than in the full contour development of bathymetric charts. The outlining contour is not limited to a fixed contour interval, and important slope changes and small relief features can be shown.

No. 13 Relation Between Oceanographic Conditions and Catch of Saury Along the East Coast of Korea

by

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The present study deals with the relationship between the fishing conditions for saury (Cololabis saira), which is one of the important coastal fishery resources of Korea, and the oceanographic conditions, laying stress on the association between the boundary zone (polar front) and the fishing grounds.

The average saury landings for the years 1950 through 1967 was 19 $\times 10^3$ M/T, showing 63% range in the annual fluctuations.

The saury fishing grounds had surface temperatures from 9° to 21°C and salinities from 31.00 to 34.70°/₀₀ along the east coast of Korea (western side of the Japan Sea). The best catches were made at water temperatures ranging from 13° to 18°C, centered at 15.44°C. The temperatures at which the best catches were made became higher with the progress of time in the spring season and lower in the autumn season. Good fishing grounds were located in waters of salinities greater than 33.00°/₀₀.

The oceanographic conditions in spring (May, June) of each year were classified in four types on the basis of the location and form of the boundary zones. The relation between the oceanographic conditions in spring and the saury fishing conditions is as follows:

Type A: The warm current type; the catch of saury was poor or good (1959 and 1960).

Type B: The distinct boundary zone type; the saury catch was very good (1962, 1965, and 1966).

Type C: The cold current type; the saury catch was very poor (1963).

Type D: The coastal upwelling type; with coastal upwelling in the southern area the saury catch was poor (1961, 1964, and 1967).

Based on comparisons of sea temperatures with saury landings from 1959 to 1967, it may be said that good and bad fishing seasons occurred during years of warm water and bad seasons always occurred during years of cold water. The relationship may not be between fishing success and water temperature per se, but rather between the location of the oceanographic boundary zone and fishing success.

No. 14 Preliminary Note on the Structure of the Kuroshio from the Biological Point of View, with Special Reference to Pelagic Fish Larvae

by

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The Kuroshio plays an important role for marine life in the northwestern Pacific, especially in regard to reproduction and recruitment as well as dispersion, migration, and growth. The present work deals with the relation between the Kuroshio and adjoining water masses in relation to spawning grounds of fish and transportation therefrom of eggs and larvae to nursery areas.

The spawning areas for Japanese sardine, anchovy, mackerel, and jack mackerel are in the coastal waters lying between the Kuroshio and the Japanese mainland, but their eggs and larvae are collected from both coastal waters and the Kuroshio area. Detailed observations on the distribution of eggs and larvae of each species showed a close relation to the horizontal and vertical structures of the Kuroshio. The water masses of the spawning grounds are entrained by the Kuroshio and form multiple belts along the landward side of the Kuroshio. On the basis of this fact, a hypothesis is proposed in regard to the relationship between the transportation route of fish larvae in the Kuroshio and the geographical position and space of the spawning grounds, as well as the length of the spawning season of fish species.

No. 15 On the Observations at the Reference Stations: Variability of Water Temperature and Salinity in the Subsurface and Deep Waters

by

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Observations at seven CSK reference stations have been made for the purpose of monitoring the secular change of the Kuroshio system and for intercalibration of techniques. In addition to the CSK data, the existing Japanese station data within 60 miles from the reference stations were used. The number of data, however, are still inadequate for the study of the secular change of the Kuroshio. The temperature and salinity variations below the depth of 200 m were studied. The standard deviations of both temperature and salinity, in general, are large at the depth of 200 m and decrease with depth. At two stations, however, large standard deviations were found at the intermediate depths, 400-600 m.

No. 16 Preliminary Results of Investigation of the Kuroshio Functioning as a Means of Transportation and Diffusion of Fish Eggs and Larvae

by

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The reproductive potential of a fish population is considered to depend greatly on the survival rate of the younger stages, such as fish eggs and larvae. Among many hydrographic

conditions which affect their survival, diffusion and transportation due to currents are especially important with respect to success or failure in their getting onto the nursery grounds.

Information on the relative importance of transportation and diffusion was obtained by (1) dye-diffusion experiments, (2) drift bottle experiments, and (3) short-interval observations along and across the Kuroshio current using BT (bathythermograph) and GEK (geomagnetic electrokinetograph).

Special surveys were carried out in the summer of 1966 by three research vessels (Soyo Maru, Shunyo Maru, and Yoko Maru) and an aircraft. The results obtained show that the diffusion coefficient is K-10^4 cm^2/sec and suggests that transportation is much more important than diffusion in the movement of fish eggs and larvae. Even so, fish eggs and larvae being transported by the Kuroshio would not reach inshore areas if the Kuroshio were a regular, steady current. Rather, this kind of transportation arises from eddies, branches, and other nonregularities of the Kuroshio.

No. 17 The Euphausiid Crustaceans of Korean Waters

by

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The euphausiid crustaceans of Korean waters collected during the course of the CSK program in the summer of 1966 and in the winter of 1967 were examined.

Ten species, representing four genera, are reported. Four numerically dominant species were Euphausia pacifica, E. nana, Pseudeuphausia latifrons, and Thysanoessa longipes. Six other species were E. mutica, E. recurva, E. similis, E. tenera, Stylocheiron affine, and S. carinatum, which have been collected spasmodically in the southern waters of Korea and were associated with the influx of the Tsushima Current.

Particular emphasis was paid to the taxonomical discrepancy between E. nana Brinton and E. pacifica Hansen. The distribution of E. pacifica was discontinuous. It was found in (1) the Japan Sea and the northern part of the Korea Strait and (2) the Yellow Sea. E. nana occurred in the intervening area, with some overlap with E. pacifica to the east and west.

No. 18 On the Study of Formalin Preservation and Shrinkage of the Indo-Pacific Mackerel Rastrelliger neglectus (van Kampen)

by

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Indo-Pacific mackerel (Rastrelliger neglectus) sampled from the wholesale fish market in Bangkok were accurately measured and preserved in Formalin solutions of fresh and sea water at various concentrations. After a period of storage of 86 days, percentage shrinkage in a particular dimension was similar but percentage shrinkage varied between various dimensions. Loss in body length ranged from 0.1% to 1.8% of the initial length and could be considered insignificant. The shrinkage of various dimensions were not significantly different among groups preserved in Formalin solutions of fresh or sea water at various concentrations.

No. 19 Research on Chemical Oceanography in the Kuroshio Around Taiwan Island

by

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Sea water samples were collected from 38 stations around Taiwan in the periods September 12 to October 13, 1965 and March 12 to April 26, 1966. They were analyzed for salinity, dissolved oxygen, pH value, inorganic phosphate-phosphorus, nitrite-nitrogen and silicate on board or in the laboratory. Maximum temperature, higher dissolved oxygen content, and higher pH values of 8.1 to 8.3 were obtained in the surface layers or the euphotic zone, and then dropped with increasing depth. In the autumn and winter, dissolved oxygen, pH values, and salinity were slightly less than in the spring and summer. In the surface layers, temperature, dissolved oxygen, and salinity in autumn were found to be 27.8° ± 1.2°C, 4.32 ± 0.29 ml/ℓ, and 34.12 ± 0.34°/₀₀; and in spring were 25.9 ± 0.9°C, 4.56 ± 0.13 ml/ℓ, and 34.49 ± 0.21°/₀₀, respectively. The salinity of the Kuroshio water was low, slightly less than 35.00°/₀₀. Inorganic phosphate-phosphorus, nitrite-nitrogen, and silicate were generally found to increase with increasing depth in the summer. From the preliminary observed results, some explanations have been formulated.

No. 20 Seasonal Variation of Oceanographic Conditions from Ocean Station Victor to the Coast of Japan Along Lat. 34°N

by

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In 1966 and 1967 a line of 16 oceanographic stations along lat. 34°N, from Ocean Station Victor (lat. 34°N, long. 164°E) to near the coast of Japan, was occupied four times by U.S. Coast Guard cutters as part of CSK. Both years the section was occupied in the winter and summer. The water properties of temperature, salinity, and dissolved oxygen content were measured at serial oceanographic stations to a nominal depth of 2,000 m.

The line is situated parallel with the axis of the major branch of the Kuroshio Extension, which has been said to flow east along lat. 35°N as far as approximately long. 160°E. The presence of the Kuroshio Extension along the line is well established in both seasons using the criterion of the near-coincidence of a salinity minimum of 33.9-34.1°/₀₀ with the sigma-t value of 26.8 under the Kuroshio. The data reveal in both winter and summer a flow east to about long. 152°E, where large vertical displacements of the isolines of all properties indicate the presence of the well-known cold intrusions and meanders in the current. At about long. 155° and 159°E there are two semipermanent cores of warm (17°-18°C), high salinity (34.7-34.8°/₀₀) water extending down to about 200 m.

Seasonal influences in the easterly flowing current from long. 141° to about 152°E resulted in the replacement of the winter mixed layer (T = 17°-18°C, S = 34.7-34.8°/₀₀) of approximately 300 m in depth with a summer thermocline (19°-25°C) and halocline (34.5-34.8°/₀₀) between 50 and 150 m. The characteristic subtropical water of the Kuroshio Extension (T = 17°, S = 34.8°/₀₀) showed a relative constancy in depth, but there was an apparent increase in the volume of this water flowing east during the summer.

No. 21 Dynamics of Meanderings of the Kuroshio and the Gulf Stream

by

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Critical reviews of hydrodynamical models of meanders of the western boundary currents are presented, including the inertia waves of a shearing current in a rotating barotropic and a two-layer system and the Rossby waves in a barotropic and baroclinic rotating ocean. Meanders in the free jet are realized in the area south of Grand Banks for the Gulf Stream and east of long. 145°E for the Kuroshio and those constrained by bottom topography occur off Cape Hatteras for the Gulf Stream and south of the main island of Japan for the Kuroshio. The eddy momentum transfer across the Kuroshio and the Gulf Stream is discussed. The effects of meanders on transfer of momentum and heat between the central Pacific or Atlantic water and the Subarctic Water are treated heuristically and recent data on the Kuroshio and the Gulf Stream are utilized to determine various transfer constants.

No. 22 Geostrophic Eddies Generated by the Kuroshio and the Gulf Stream

by

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Case histories of warm eddies generated by the Gulf Stream off Cape Hatteras in 1965 and 1966 are discussed, and their dynamical structures are compared with those of warm eddies from the Kuroshio east of the mainland of Japan. Statistical comparison of cyclonic and anticyclonic eddies along the Kuroshio and the Gulf Stream is made by use of data collected since 1953, including the CSK data for the Kuroshio and data from the Gulf Stream '60 and by the U.S. Coast and Geodetic Survey cruises in 1965-66. Dynamics of generation of eddies in a rotating barotropic or baroclinic flow are discussed.

No. 23 Studies on Environments Attracting Skipjack and Other Tunas

by

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The object of this paper is to clarify the characteristics of driftwood on the ocean that are accompanied by skipjack and tunas from close observation of the wood itself. In 1952-63 the authors had opportunities to obtain the data on the driftwood through cooperation of many commercial fishing vessels and R/V Tokaidaigaku Maru. The wood followed by skipjack and tunas showed a peculiar biological environment for shipworms and other shells attached on the outside or the inside of wood. Dominant animals found on the driftwood that were accompanied by skipjack and tunas were Teredora aurita and Lepas anserifera. Dominant sessile animals on driftwood that were not accompanied by skipjack and tunas were L. anserifera, which were found in plenty, Planes minutus, and barnacle, Balanus sp. The difference between wood accompanied by skipjack and tunas and those not accompanied by these

fish seems to lie in the presence or absence of T. aurita. Judging from the length of the burrows caused by T. aurita, the authors presume that driftwood begin to attract skipjack and tunas behind them while the driftwood were drifting on the sea for at least 1 year.

In order to clarify the relation between the driftwood and the boring and sessile animals and the route of the driftwood, etc., the authors made a series of marking experiments, releasing experimental driftwood of lauan in the area southeast of Formosa and in the eastern waters of Mariana Islands in 1964 and 1965. The experimental driftwood was recovered at a rate of about 5%. As compared with the natural driftwood, the driftwood recovered showed a remarkable difference in the appearance. The reporters who recovered the experimental driftwood reported that they were not followed by skipjack and tunas at the time of the recovery on the sea.

On the experimental driftwood recovered in this experiment, the predominance of T. aurita which had developed on the natural driftwood that were followed by skipjack and tunas could not be seen, perhaps because the drifting period of the experimental driftwood was too short. Further on experimental driftwood which had been set out on the Izu coast for comparison, L. anserifera of big shell, Amphipoda sp., and Balanus tintinnabulum, which were seen in plenty predominant on the natural driftwood could not be seen.

Accordingly further studies on the mechanism attracting skipjack and tunas to a driftwood are necessary. To release the experimental driftwood in more southern seas than the waters adjacent to Taiwan and to research the environment of the places where many driftwood are gathered by wind or sea current seem to be necessary.

No. 24 Synopsis of Biological Data on Threadfin Bream Nemipterus hexodon (Quoy and Gaimard) 1824

by

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Information on the taxonomy, nomenclature, distribution, bionomics and life history, population, and exploitation of Nemipterus hexodon is summarized.

No. 25 On the Coastal "Kyucho" and the Movement of the Branch Current of the Kuroshio

by

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In mid-August of 1966 a strong and sudden flow called the "kyucho" swept over the set-net fishing grounds in Tateyama Bay, and some fishing equipment was damaged by this strong current. The "kyucho" occurs sometimes, especially during the period from winter to spring at specific locations along the coast of Japan, but it is singular for it to occur in the midsummer. The Tateyama "kyucho" was observed just after noon on August 15 at the mouth of Tateyama Bay, and then propagated progressively inside the bay. The estimated speed of the "kyucho" was over 2-3 knots. Owing to this, the surface and subsurface water temperatures suddenly rose about 2°C and the transparent oceanic water replaced the dark green bay water.

It is evident that this "kyucho" was brought about by an inflow of the Kuroshio branch current. From the beginning of mid-August the axis of the Kuroshio tended to approach the Pacific coast of eastern Japan. In that time the northeastward-moving "mashio" current intensified near the Mera-se Bank, which is outside of Tateyama Bay, while the movement of water in the bay was not so fast. Thereafter, just after noon August 15, the speed of water movement suddenly increased along with the increasing of flood current (the age of the moon: 28th) near the set-net fishing ground located at the mouth of the bay.

Based on these facts it is considered that the strong flood current broke the dynamical equilibrium between the oceanic and the bay waters and led the water of Kuroshio origin into the bay. In this case there was not any data showing the direct influence of the meteorological current on the "kyucho." In this August, however, two developed typhoons passed across the Kuroshio, and so it may be necessary to consider the effect of the barometric current on the Kuroshio Current itself.

No. 26 Geographical Distribution of the Bottom Fishes in the Southwestern Waters of Korea

by

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As part of the CSK, studies were made of the geographical distribution of bottom fishes during 1965 and 1966 in the southwestern waters of Korea, using a 130-foot trawl net on 10 stations.

We obtained the following results:

1. Families and species sampled: 50 families, 91 species.
2. Average number of species per station: 5.1 species.
3. Eopsetta grigorjewi was the most frequently occurring species, appearing at 65% of the sampling stations.
4. According to the correlation coefficient presented by Otsuka, the degree of correlation between fishing grounds south and north of Huksan Island (lat.34°40'N) suggest the existence of a zoogeographical boundary.

No. 27 A Contribution to the Knowledge of the Growth of Saurida undosquamis Richardson in the Gulf of Thailand

by

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Monthly length-frequency curves of Saurida undosquamis from two locations in the Gulf of Thailand are presented. Off Trat (east coast) there seemed to be two spawning seasons; in May-June and in September. The growth rate is about 1.4 cm per month, so that the fish reach 17-18 cm in total length in their first year. Off Prachuap Khiri Khan area (west coast) there seemed to be no resident population of S. undosquamis. The length-frequency

distribution indicates that the species migrates freely to and from this location. The distribution by depth shows that on the average bigger specimens prefer the depths of 30-40 m, although they were caught often at depths of 20 m. Only in August-September was a considerable number of fish caught off Trat area at depths as shallow as 10 m. More detailed studies of the species of the genus Saurida are planned for the near future.

No. 28 Hydrological Conditions and Biological Characteristics of the Kuroshio Waters in Area Lat. 43°-20°N and Long. 138°-149°E

by

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The report comprises the results of complex investigations during summer 1965 and winter 1966 in the area between lat. 43°-20°N and long. 138°-149°E. Three main zones in the area under discussion are distinguished; namely, subarctic zone, zone of mixing, and Kuroshio Current proper. Data are given on the determination of primary production by means of the radiocarbon method. The relations between distribution of plankton and hydrological conditions are defined.

Great seasonal variation is noted. In the area bounded by lat. 32°-34°N and long. 138°-149°E biological spring begins in February-April and summer lasts from July-October. In the area bounded by lat. 27°-24°N and long. 138°-149°E heavy blooming of the bluegreen alga Oscillatoria thiebautii took place. This alga is found in great quantities in Kuroshio Current zone.

The abundance of phytoplankton in the southern region in summer was 49 mg/m^3. The general volume of mesoplankton was 210 mg/m^3 during February-April and 613 mg/m^3 during July-October. In the southern part of the northern region it was 230 mg/m^3 in winter and 292 mg/m^3 in summer in the 0-150 m layer. The total abundance of macroplankton in both seasons did not differ much. However, the abundance of certain groups differed considerably from the winter period to the summer.

The main features of fish distribution during the summer and winter periods are described.

No. 29 Investigation of the Short-Period Variations of the Path of the Kuroshio by Airplane

by

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From October 1965 to January 1967, short-period variations of path of the Kuroshio Current to the east of Japan were investigated. The paths of the Kuroshio were identified with the aid of the sea surface temperature distributions measured by the A.R.T. (Airborne Radiation Thermometer) and also by the distributions and orientations of the "shiome" or current rips observed from the airplane.

After considering the possibilities and limits of the presumed current paths, the variations of the path were studied graphically. The current paths in the stated sea area seem to generally be classified into two types: type I flows directly east-northeastward

passing through the northern part of the Izu Islands, and flows away to the northeast of Japan, and type II makes a detour to the southern part of the Izu Islands and then flows northeastward to the same area.

These two types of path appear alternately and very frequently in the stated area.

Besides the above results, the following empirical formula for improving the degree of precision of A.R.T. values was obtained:

$$T_{obs.} = (0.51 + 0.07w)T_{surf.} - (0.07w - 0.49)T_{air} - 0.6$$

$T_{obs.}$ = A.R.T. value, $T_{surf.}$ = so-called sea surface temperature.
w = wind speed in m/sec at the sea surface.
T_{air} = air temperature at the sea surface; altitude = 1,500 feet.

No. 30 Temperature and Current in and near the Kuroshio Current

by

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Towing a thermistor chain through the Kuroshio Current east of Japan has provided over 1,000 km of two-dimensional data on sea temperature structure, extending from the surface to 240 m. Relative current was determined at four levels along the chain.

It was found that the vast flow and turbulence in the world's major current, the Kuroshio, greatly affect the detailed thermal structure. The two-dimensional picture shows that the low-frequency, long waves, with irregular wavelengths of several miles, are more evident in the Kuroshio region than in any other measured area in the North Pacific. Many vertical oscillations depicted by isotherm depths in the weaker parts of the thermocline are as great as 20 m, but in the strong thermocline are usually less than 10 m. The isotherm depth changes at some levels are in phase; at others they are not.

Statistical treatment of the successive recorded isotherm depths reveals that outside the Kuroshio the median absolute slope in the main thermocline varied between 8 and 29 minutes. Similar slopes of an isotherm just below the main thermocline gave values of 11-35 minutes.

The power spectrum of changes in the depth of isotherms shows no dominant peaks and thus indicates a more irregular thermal structure with a wide spectrum of wavelength suggesting large-scale turbulence. The relative shear flow in the Kuroshio showed a difference of speed in the direction of tow of as much as 3.9 knots in a vertical distance of 200 m and in one location 3.0 knots in 70 m.

Where the Kuroshio comes in contact with a narrow tongue of the Oyashio, a sharp internal front was recorded with a horizontal temperature change amounting to 0.44°C per km. At this subsurface western boundary with the Oyashio there was a convergence circulation of 0.3-0.5 knot. The vertical temperature structure over the Oyashio is strong, amounting to as much as 10°C in 13 m.

No. 31 Monthly Extremes of Temperatures in the Surface Waters South of Japan

by

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In compiling an oceanographic atlas of the North Pacific Ocean, charts of the monthly extremes of surface temperatures were prepared to supplement the monthly mean temperature charts in areas where complexities were disguised by averaging. These analyses, based mainly on ship injection temperatures plotted on a 1° quadrangle grid, were based on a period of data collection of more than 100 years.

This study deals with the oceanic features shown by these monthly extremes in the waters south of Japan. While the 12 monthly temperature charts of mean conditions show the effect of the north and south solar migrations, the 12 maximum charts clearly indicate the origin of the Kuroshio in the waters east and north of the Philippines, as well as the positions of the North Equatorial Current and Equatorial Countercurrent. In addition, large cells of extremely warm water showing seasonal continuity appear on the maximum charts. The potential hydraulic head that these cells must furnish to the Kuroshio, as well as to the Equatorial Countercurrent, indicates a need for further study.

The monthly minimum charts show a different picture of generally weak development of the Kuroshio during some years, as well as a more westward extension of the comparatively cooler waters of the North Equatorial Current than normal.

In general, the distribution and amount of data in this study area were sparse in comparison to other regions of the Pacific. This difference was especially noticeable on the extreme charts, where no data were plotted in 1° quadrangles containing fewer than 10 observations. The continuity of the charts, however, both areally and seasonally, gives a good indication of their reliability.

No. 32 Drift Bottle Experiments in the Eastern Yellow Sea, 1962-66

by

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Surface currents in the eastern Yellow Sea were investigated by six bottle experiments during the period 1962-66. A total of 4,374 bottles were released and 488 (11%) were recovered. The results were:

1. The recovery rate was higher during the time of the northerly warm coastal current (summer) and lower during the southerly cold coastal current (winter).

2. The greatest number of recoveries was generally in the area between Chejudo and Junra-namdo regardless of month of release.

3. The term of northward flow of the warm current was April-August.

4. The term of southward flow of the cold current was from September to March.

5. Easterly flow in the Cheju Strait was observed through the whole season; in April-

May it was composed of both the warm current that had passed to the west of Chejudo and the coastal southward current; during August-September it was the warm current; and during October-March it was composed of both the southward coastal cold current and the circulating current system of the Yellow Sea.

No. 33 On the Chaetognaths Collected from the Waters Surrounding Taiwan During CSK Cruises

by

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Chaetognaths collected from Taiwan waters during 1966 and 1967 CSK cruises have been analyzed for their species composition and relative abundance at some of the hydrographic stations. Seventeen species have been identified. Among them, Sagitta pacifica and S. enflata were the two most abundant and most frequently found species. Because of the scarcity of the available data, correlation between distribution and hydrographical conditions has not been attempted. However, the distribution of certain species did show certain obvious patterns.

No. 34 Influence of the Komandorskiy Ridge on Surface and Deep Circulation in the Western North Pacific Ocean

by

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Data are presented from a series of hydrographic stations taken from the R/V George B. Kelez during February and March 1966. Observations from 18 of the 34 stations extended below 4,000 m. Stations were taken in eight crossings of the Komandorskiy Ridge (northern extent of Emperor Seamount Chain) between lat. 45° and 53°N. The data have been compared with previous deep stations in this region and with a model of the general circulation in the North Pacific Ocean.

The Komandorskiy Ridge extends southward from the Komandorskiy Islands; it lies almost normal to the westward flow of the Alaskan Stream and the eastward flow which results from the confluence of the Kuroshio and Oyashio Currents. The Komandorskiy Ridge marks the westernmost extent of the Alaskan Stream as a well defined feature, the Alaskan Stream being deflected mainly to the north at the ridge. The Kuroshio-Oyashio flow shows little disturbance, but the presence of the ridge appears to inhibit any deep circulation in this region.

Previous summer observations in this region showed similar flow; the observed distributions and transports are consistent with a generalized model circulation in the North Pacific Ocean.

No. 35 Zooplankton Distribution and Abundance in the Lamon Bay and Approaches

by

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Plankton samples were collected from 91 stations during an oceanographic fishery exploratory survey off the eastern part of Luzon Island, covering the region from the coasts of the Quezon-Bicol province up to 15°20'N as the northern boundary and 124°30'E as the eastern boundary. The zooplankton volume (wet) per unit area varied greatly. The standing crop is very low in the eastern part of the region surveyed. The zooplankton composition is heterogeneous.

The density distribution was characterized by more or less isolated patches.

No. 36 Results of the Joint Thai-Malaysian-German Trawling Survey off the East Coast of the Malay Peninsula, 1967

by

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and
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The Thai-Malaysian-German joint trawling survey off the east coast of Malay Peninsula was carried out under an ASA Project by means of a Thai Department of Fisheries research vessel, Pramong 2 (76 gross tons, 23 m long) from March 1 to April 11, 1967. The gear used was a German type otter board trawl net having a cod end mesh size of 4 cm and the opening width between the danlenos of 20 m. The objective of the survey was to explore the possibilities of trawl fishery development along the east coast of the Malay Peninsula. The whole survey region, from the Thai-Malaysian border to the most southern tip of the east coast of Malay Peninsula was divided into four subareas in each of which 40 hauls of 1-hour duration each were made, totaling 160 hauls for the entire survey region. The depths trawled ranged from about 10 to 60 m.

Average catches per hour per subarea ranged from 745 kg to 183 kg. The average catch per hour in the 21-30 m depth zone was 646 kg; in the 51-60 m depth zone it was 202 kg. For the entire area, fish for human consumption amounted to 63% of the catch. The percentage of scrap fish decreased with increasing depth.

A brief account of tagging techniques and operation conducted in conjunction with this survey is also included.

No. 37 An Oceanographic Section from Japan to New Guinea at Long. 137°E in January 1967

by

Jotaro MASUZAWA
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A long meridional oceanographic section was made at long. 137°E from Japan to New Guinea in January 1967 on board the R/V Ryōfu Maru for the CSK. The section involved the Kuroshio, its countercurrent, weak currents in the subtropics, the North Equatorial Current, the Equatorial Countercurrent, and the Equatorial Undercurrent. The descriptive features of these currents, such as width, geopotential difference, geostrophic flux, and water characteristics are demonstrated. The salinity minimum in and south of the southern part of the North Equatorial Current is different in thermosteric anomaly from the salinity minimum in and north of the northern part of the North Equatorial Current, so that the former minimum may not be a direct southward extension of the latter minimum. Waters of the Equatorial Countercurrent and Undercurrent consist of medium-sized water masses both from the North Equatorial Current and from the South Pacific.

No. 38 Potential Demersal Fish Resources of the Sunda Shelf

by

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Department of Fisheries, Bangkok

Available information on the exploratory trawling surveys off demersal fish resources and a brief review of the existing trawl fisheries of the Sunda Shelf are presented.

Results of the previous trawl fishing surveys indicated that the coastal waters of Thailand, the waters off the east coast of West Malaysia, off the west and south coasts of South Viet Nam, around Natuna and Anambas Islands, and off North Borneo and Sarawak were abundant in demersal fish resources. However, in the Gulf of Thailand, due to the rapid expansion of the commercial trawl fishery during the past 5 years, there is an indication that the abundance of the demersal fish resources in the Gulf has declined steadily.

In the central part of the Sunda Shelf, the grounds were relatively barren. Exploratory trawlings over these grounds yielded poor results.

It is recommended that trawling surveys be repeated in the central part of the Sunda Shelf, in the waters around Natuna and Anambas Islands, and off the North Borneo and Sarawak coasts, in order to arrive at definite conclusions as to the status of the resources in these waters. Exploratory trawling surveys should also be initiated in the Java Sea.

The intercalibration of research trawlers and trawl fishing gear is suggested in order to permit comparisons of the catch data obtained by various research trawlers operating in these areas in the future. The establishment of a suitable logbook system to obtain catch and effort data from commercial trawlers fishing on various grounds of the Sunda Shelf is also recommended.

No. 39 Report on the Preliminary Processing of Zooplankton Standard Samples in Japanese CSK Studies, 1965-66*

by

Sigeru MOTODA, Faculty of Fisheries, Hokkaido University, Hakodate;
Haruhiko IRIE, Faculty of Fisheries, Nagasaki University, Nagasaki;
and Isamu YAMAZI, National Science Museum, Tokyo

Data on the biomass in wet weight for a total of 325 samples of zooplankton taken by standard haul (0-150 m) with a Norpac net (45 cm x 180 cm, conical, 0.33 mm^2 mesh openings) from Japanese ships during CSK cruises in 1965-66, are plotted in charts. Generally speaking, 50-100 mg/m^3 of biomass in wet weight exists in the Kuroshio area. The contour of 100 mg/m^3 shifts northward in the cold season, southward in the warm, suggesting that the plankton-rich water from the East China Sea expands southward in the warm season.

Standard samples taken by Japanese ships during 1956-66 are being sorted at the National Science Museum in Tokyo. Up to the present, 150 of 428 samples have been preliminarily sorted into 23 categories. Biogeography of zooplankton in relation to the oceanic current system can be studied when all specimens in the sorted groups have been identified by specialists.

No. 40 Biological Structure of the Sea on the 142°E Line in the North Pacific with Particular Reference to the Interrelation Between Living and Nonliving Organic Matter

by

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Observations at a series of oceanographic stations along long. 142°E between lat. 20° and 30°N occupied by the Oshoro Maru during CSK in January 1966 and January 1967 included daily primary production, chlorophyll *a*, phaeophytin *a*, plankton mass (wet weight, dry weight, carbon and nitrogen), total seston mass (dry weight, carbon and nitrogen), major inorganic nutrient salts and dissolved organic nitrogen.

Average standing crops of zoo- and phytoplankton and standing reserves of nutrient salts in the euphotic layer are briefly summarized separately for the areas north and south of the subtropical convergence. Phytoplankton standing carbon converted from chlorophyll *a* varies in a range of 1.28-1.53 gC/m^2, and is 3.6 times in the north and 6.9 times in the south of the zooplankton standing carbon.

The phosphate reserves in the euphotic layer correspond to 30-50 days' need of the phytoplankton standing population. However, the concentration of phosphate is far below

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* The writers submit this report in the capacity of representatives of zooplanktologists in various institutions in Japan participating in zooplankton studies on CSK cruises during 1965-66.

** Representing participants in biological research on CSK cruises by the Oshoro Maru, January 1966 (cruise 16) and January 1967 (cruise 21): Y. Akiba, H. Ishii, A. Kawamura, T. Kawamura, Y. Maita, T. Minoda, Y. Morioka, S. Motoda, K. Nakajima, S. Nishizawa, K. Ohtani, I. Okubo, and A. Taniguchi.

the generally accepted limiting level. The inorganic nitrogen reserves are about 60 times the phosphate reserves, so that the N/P ratio is fairly high. However, 33-56% of the inorganic nitrogen is in the form of ammonia.

Calculated respiration requirements by the zooplankton standing population are not satisfied by the estimated ingestion of standing crops of phytoplankton. If the nonliving organic matter contained in seston can be the objects of zooplankton feeding, the requirements are nearly satisfied.

No. 41 Some Results of Investigations of the Dynamics and Thermal Structure of the Kuroshio and Adjacent Regions

by

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Hydrometeorological Service, Moscow

Data collected as part of the CSK program permitted for the first time determination of some features of circulation and thermal structure of the ocean from 43° to 20°N and from 155°E west to the Philippines in the summer seasons of 1965 and 1966 and the winter seasons of 1965-66 and 1966-67.

Marked variations were noted in some flows composing the circulation of the region. The Kuroshio Current meandered significantly in 1965 and in the winter of 1965-66 and was displaced to the north and smoothed directionally in the summer of 1966 and in the winter of 1966-67. Thus, the high dynamics of the Kuroshio front area was noted in the first case and its attenuation in the second case. Depending on the Kuroshio flow location, there is a Kuroshio countercurrent that was most developed in the summer of 1966 and in the winter of 1966-67.

A new link was found in the circulation scheme, i.e., a subtropical frontal countercurrent that seems to be a result of the frontal gyrals developing at the corresponding latitudes.

The heat content of the water layer of 0-150 m varied noticeably. In the summer of 1965 it was less than in the summer of 1966. During the winter seasons of different years noticeable deviations occurred in some regions. The subsurface layer with high heat-content (at depth of 150-500 m) corresponds to maximum salinity layer; an intermediate layer of low heat-content corresponds to minimum salinity and oxygen layer.

No. 42 Synopsis of Biological Data on Hawaiian Species of Stolephorus

by

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Data on identity, distribution, bionomics and life history, population, and exploitation of the nehu (Stolephorus purpureus) are summarized. The nehu, an engraulid fish, is used as live bait in the skipjack tuna (Katsuwonus pelamis) fishery in Hawaii. Data on the identity and distribution of the roundhead (S. buccaneeri), a second Hawaiian engraulid, are also summarized. The taxonomic status of the roundhead has been questioned, since morphological intermediates between it and the nehu have been found.

No. 43 Oceanographic Conditions in the Western Philippine Sea and Luzon Strait in the Summer of 1965 and 1966

by

Hideo NITANI
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The R/V Takuyo carried out oceanographic observations in the western Philippine Sea and Luzon Strait in the summer of 1965 and 1966 as a part of CSK synoptic survey. Results show:

1. The North Equatorial Current is separated clearly into two branches off Luzon Island at lat. 13°-14°N. The northward-moving one is the Kuroshio and southward-moving one is the Mindanao Current. The Kuroshio flows north along the coast of Luzon Island with a velocity of about 1.5-2.0 knots and enters Luzon Strait; then it turns to the northeast and flows out into the Pacific. The water of the northern half of the North Equatorial Current is the origin of the Kuroshio and the current off Luzon Island is to be called the beginning of the Kuroshio. The transport of the Kuroshio here is about two-thirds to three-fourths that of the Mindanao Current.

2. There are two semipermanent eddies in this area. One is a warm-core eddy on the east side of the Kuroshio in Luzon Strait and the other is a cold-core eddy off Mindanao Island.

3. The North Pacific Intermediate Water forms the lower part of the Kuroshio.

4. The transport of the Kuroshio off Luzon Island and in Luzon Strait is about 30-45 x 10^6 ton/sec, which is smaller than that of the Kuroshio off the south coast of Japan.

No. 44 On the Variability of the Velocity of the Kuroshio—II

by

Hideo NITANI and Daitaro SHOJI
Hydrographic Office of Japan, Tokyo

Investigations on the variability of the Kuroshio, using two or three vessels at the same time, were carried out in October of 1964, 1965, and 1966.

GEK and BT observations crossing the Kuroshio and steric observations at both sides of the Kuroshio were continued for about 1 week. The results in 1964 were published in the Journal of the Oceanographical Society of Japan, vol. 22. The present paper deals with the results obtained in 1965:

1. The dynamic height anomaly at the north boundary of the Kuroshio off Kushimoto agreed comparatively well with the sea level at Kushimoto.

2. The observations showed that semidiurnal variation was predominant, while in 1964 diurnal variation was predominant. Variations of the parallel and perpendicular components of velocity of the Kuroshio were of nearly the same order and the velocity vector rotated clockwise with a semidiurnal period.

3. The observed velocity fluctuation is nearly geostrophic apparently, but observed changes of sea level for long (several days) and short (semidiurnal) periods are

larger and smaller than those expected from the geostrophic balance. When the current becomes strong the sea level falls at the north boundary and rises at the south boundary like a seesaw.

4. The relation between the velocity and the position of the center of the Kuroshio was discussed.

No. 45 Epiplanktonic Cephalopod Larvae in the Kuroshio

by

Takashi OKUTANI
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Decapod cephalopod larvae taken from the sea surface on the Pacific coast along the Japanese Islands by the 1.3-m larva net of the R/V Soyo Maru during 1960-66 were examined. The identified larvae are:

Idiosepius pygmaeus paradoxus Ortmann, 1888
Sepiola birostrata Sasaki, 1918
Euprymna morsei Verrill, 1881
Doryteuthis bleekeri (Keferstein, 1866)
Watasenia scintillans (Berry, 1911)
Abralia sp.
Octopodoteuthis sp.
Onychoteuthis banksii (Leach, 1817)
Onychio carribaea Lesueur, 1821
Todarodes pacificus Steenstrup, 1880
Ommastrephes bartrami (Lesueur, 1821)
Liocranchio reinhardti (Steenstrup, 1856)

The myopsid species mostly occur in the coastal waters. Watasenia occurs in the transitional zone where a subarctic species, Gonatus fabricii (Lichtenstein, 1818), frequently occurs in winter. Onychoteuthis, Onychia, and Abralia are found in the Kuroshio or the adjacent warm areas. Todarodes seems to be transported by the Kuroshio from the breeding area north to the Pacific coast of northern Honshu.

No. 46 Tagging of Skipjack Tuna (Katsuwonus pelamis) in Palau

by

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Honolulu

The Bureau of Commercial Fisheries Biological Laboratory, Honolulu, Hawaii, initiated a skipjack tuna tagging program in the Palau Islands, Western Carolines, in June 1967 in cooperation with the Government of the Trust Territory of the Pacific Islands. As of mid-March 1968 five tagged fish have been recovered.

No. 47 The Distribution of Chaetognaths in Korean Waters, Particularly in the Southern Waters, and Their Relation to the Character of Water Masses in the Summer of 1967

by

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Fisheries Research and Development Agency, Pusan

The material collected from a cruise for the CSK in Korean waters during the period August 10-25, 1967 was studied to determine the species of chaetognaths present, to establish their distribution within those waters, and to investigate the possibility that certain species of chaetognaths found in the region can serve as biological indicators of oceanographic conditions. The collections were made by vertical and horizontal hauls with Norpac and larva nets.

The general oceanographic features of the Korean waters are described. The distribution and frequency of occurrence of 20 species of chaetognaths are described and discussed. Among these species, predominant species are as follows:

Sagitta bedoti is a species widely distributed at all stations. In the southern part, this species was more abundant in the region to the southwest of Cheju Island than others. It may prove to be an indicator of the cold water masses and mixed water located southwest of Cheju, because of its low frequency of occurrence in the central Kuroshio.

Sagitta crassa, a neritic form, was distributed in abundance in the cold water region influenced by the western waters of Korea, west of long. 126°30'E, but it was not found at all in the warm Kuroshio Current, so we may be able to determine the extent of the area influenced by that water.

Sagitta enflata was the most abundant of all species, and was found predominantly in the central Kuroshio. As warm water forms, S. minima, S. regularis, S. serratodentata, S. neglecta, S. robusta, Krohnitta pacifica, and Pterosagitta draco are the most common species and were relatively widely distributed throughout the Kuroshio warm water except those with a low frequency of occurrence in the region where the Kuroshio was mixing with cold water masses. The distribution of chaetognaths in the southern sea of Korea is determined by the Kuroshio Current, cold water masses, and coastal water.

On the other hand, Sagitta elegans is restricted to the area influenced by cold water in the eastern sea of Korea, and then it was a valuable indicator to determine the extent of cold currents and cold water of the bottom layer.

No. 48 Some Results of the CSK Investigations Carried Out by the Research Vessels of the U.S.S.R. Hydrographic Service

by

A.A. ROGOTSKY
Hydrographic Service, Vladivostok

Investigations of the Kuroshio by the Hydrographic Service of the Soviet Navy were begun by the R/V Ulyana Gromova in the summer of 1965. Twenty-eight complete (to the bottom) hydrologic stations and 34 suspended (to lesser depths) hydrologic stations were taken. In summer and in winter, 1966, the research oceanographic vessel Nevelskoy went on with the investigations. Forty-two complete hydrologic stations and 79 suspended hydrologic

stations were taken. In 1967 the investigations were carried out by the Ulyana Gromova at the beginning of the year and by the Nevelskoy at the end of the year. In 3 years of investigations, 245 hydrologic stations were taken in the area of the Kuroshio Current by the research vessels of the Soviet Navy.

As a result of these investigations, information was obtained on the characteristics of the areal structure of subpolar front, the main stream of the Kuroshio, and the temporal changeability of the main hydrologic elements.

However, the problem of the establishment of the regularities of the areal-temporal changeability of vertical and horizontal structure of the Kuroshio Current and the influence of frontal processes on the forming and changeability of the vertical and horizontal structure of the Kuroshio are not still worked out.

Thus it is necessary to continue the investigations in the area from 20°N to the Equator, between 130° and 155°E and in the area of the South Kuril Isles between 34° and 46°N.

No. 49 An Illustrated Key to the Genus Stolephorus

by

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The clupeoid fishes (herrings and anchovies) form the most important single group of fishes exploited by man. In the Indo-Pacific region, anchovies play a considerable part in fisheries, but their small size, similarity in general appearance, and wide variability in certain meristic features make them difficult to identify. Much biological work has suffered from poor identifications of material.

In the Indo-Pacific region there are about 43 species of anchovy, placed in 8 genera, of which the genus Stolephorus is perhaps the most important and certainly the most confusing for fishery workers. In this paper the genus is distinguished from the very similar genus Engraulis, and a key is given to the 14 species of Stolephorus recognized. New characters are used to separate the species, including the shape and size of the posterior frontal fontanelles, the outline of the hind border of the preoperculum, the prominence of the supraorbitals, the shape and length of the upper jaw, variability in the numbers and position of the prepelvic scutes, and the range in gill raker numbers on the first and third arches.

Of the 14 species recognized, 3 are believed to be new and will be described later, together with a re-description of the remainder and designation where necessary of lectotypes and neotypes. The majority of species are very wide ranging, but two (S. holodon and S. purpureus) are restricted, respectively, to South Africa and Hawaii.

Over 7,000 specimens were examined and in many cases this was the first time that specimens had been studied from the whole range of a species. Specimens were examined in the collections of the Zoological Survey of India (Calcutta), the Museum National d'Histoire Naturelle Paris), the Universitets Zoologiske Museum (Copenhagen), and the British Museum of Natural History (London).

No. 50 Particulate Organic Matter in Southern Seas off the Midcoast of Japan

by

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Particulate organic carbon and nitrogen were determined at 11 stations along long. 142°E, from lat. 37° to 22°N during the CSK cruise of Hakuho Maru, Ocean Research Institute, Tokyo University, in September 1967. In near-surface layers, the organic carbon ranged from 20 to 50 mg/m^3 and the organic nitrogen from 3 to 7 mg/m^3. On the other hand, from 200 m to 4,000 m, carbon and nitrogen values were quite homogeneous, i.e., in ranges 10 $\pm$ 5 mg/m^3 and 1.0 $\pm$ 0.5 mg/m^3, respectively. The corresponding values of pheopigments in the deep layer, as determined for the same samples as used for the determination of carbon and nitrogen, were also nearly uniform. The ratio of organic carbon to nitrogen was 6 to 8 and 10 to 15 in the upper layers and the deeper layers, respectively. Comparing these results with those of coastal waters, the cause of this homogeneous distribution of organic particulate substances in deep waters will be discussed.

No. 51 Primary Production in the Kuroshio Area

by

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Shoji IIZUKA, Faculty of Fisheries, Nagasaki University, Nagasaki;
Yusho ARUGA, Tokyo University of Fisheries, Tokyo; and
Kaoru TAKESUE, Shimonoseki University of Fisheries, Shimonoseki

Photosynthesis and plant pigments were measured during the CSK cruises of several Japanese ships. The daily photosynthetic production was 0.1 to 0.2 gC/m^2/day in the greater part of the ocean area, while it was rather high, with values 0.4 to 0.6 gC/m^2/day, in the area of continental shelf as well as in regions near islands.

During 1965-66 plant pigments were determined by the so-called "Richards and Thompson" method. From 1967 the method was replaced with the fluorometric method which enabled separate measurements of chlorophyll a and pheopigments aboard the ship immediately after sampling.

The amount of plant pigments in the upper layers was found to change considerably in different seasons and in different areas, although the general pattern of distribution was almost the same as that of photosynthetic production. At every station the amount of plant pigments was low and rather constant from the surface down to a depth about 50 m, and the maximum value was observed in a layer between 50 m and 125 m. The depth of this maximum tended to move deeper at lower latitudes. It is also notable that even when this layer of maximum lay below 100 m, not only a considerable amount of chlorophyll a but also a rather active photosynthesis was yet observed there. The ratio of chlorophyll a to pheopigments, as determined as "acid factor," decreased with depth, and at 200 m depth the greater part of the chlorophyll pigments was found to consist of pheopigments. Abnormally high values were obtained for acid factor in the area where a heavy blooming of Trichodesmium was observed.

No. 52 Oceanography of the Boundary Waters Along the Kuroshio Current in the Southern Part of the East China Sea

by

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The Kuroshio Current, which probably has its source to the east of the Philippine Islands, appears to build up its character as it continues to the northeast between the north coast of the Ryukyu Islands and the shallow areas of the East China Sea. Along this course, the Kuroshio water is in contact with the water of the colder East China Sea and, therefore, it may be probable that there are extensive and active exchanges between the Kuroshio water and the China Sea water. In addition, possibilities of vertical mixing in the current, horizontal mixing along the current, and any transfer processes across the Kuroshio Current cannot be neglected.

The author examined the above-mentioned processes on the basis of the CSK data obtained in the years of 1965 and 1966 and reports the preliminary results.

No. 53 On the Preparation of an Illustrated Key for Saurida (Lizardfishes) in the Indo-Pacific Waters

by

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Nagasaki

I have been asked to prepare an illustrated key for Saurida (lizardfishes). At present, however, it is a rather difficult problem to prepare a complete key to the Indo-Pacific species, because the writer does not have sufficient access to the literature to acquire the complete information which is necessary to do it. The present paper is, therefore, only a very rough draft of the key to Indo-Pacific species with emphasis on species taken from Japanese waters and from the East China Sea.

According to the recent papers written by Anderson, et al. (1966a), nine species of Saurida are known from various part of the warmer seas of the world. Four of these are Atlantic species, and the other five are Indo-Pacific, namely, S. tumbil (Bloch) 1795, S. gracilis (Quoy and Gaimard) 1824, S. elongata (Temminck and Schlegel) 1846, S. undosquamis (Richardson) 1848, and S. longimanus Norman 1939. Three species among them, that is, S. tumbil, S. elongata, and S. undosquamis, occur in the Japanese waters and in the East China Sea.

The record indicates that, of the above three species, the first listed is most abundant, the second less abundant, and the third least abundant. The annual yield in the East China Sea for all countries reaches about 40,000 tons for S. tumbil and 15,000 for S. elongata.

The classification of the Japanese species of this genus had been in a state of confusion until J.R. Norman (1935) made a detailed study of the lizardfishes of the world. In

his paper, he referred to nine species[1/] under Saurida, of which, the three species mentioned above are known from Japanese waters. However, the identification of these three species was not so clear. In 1950, Tatara studied these species taken from the East China Sea, and found several important characteristics to distinguish them. Thereafter, Matsubara and Iwai (1951) carried out a very close examination of many external and internal characters on these species, so the method of identifying Japanese species of Saurida has been made much clearer.

As a result of a preliminary examination of papers and other information now available, the writer concludes that the problem of the entire Indo-Pacific species has already been quite satisfactorily dealt with by Norman (1935, 1939), except for a few remaining questions which will be considered later in this paper.

No. 54 Continuous Measurement of Subsurface Temperature by Submarine Cable: a Preliminary Report

by

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Hydrographic Office of Japan, Tokyo

It is now well known that the Kuroshio changes its position and strength very rapidly in the area south of Honshu. To monitor this rapid variation of the Kuroshio, the Hydrographic Office of Japan installed tide gauges on the islands of Hachijo, Miyake, and Kozu. To supplement these sea level observations and to understand what is happening in the sea, submarine cables with thermistors were laid to measure the subsurface temperatures at Miyake and Hachijo recently.

The length of the cable is about 1,500 m and the deepest sensor is located 110 m deep for Hachijo; the figures are 2,500 m and 200 m, respectively for Miyake. The temperature is recorded continuously on the shore.

It is expected that these continuous records will be very useful for the understanding of the Kuroshio.

No. 55 Estimation of Age and Growth of Chub Mackerel (Rastrelliger neglectus van Kampen) off the Western Coast of the Gulf of Thailand

by

Prakorp SUCONDHAMARN, Chujit TANTISAWETRAT, and Usa SRIRUANGCHEEP
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The age and growth of Rastrelliger neglectus inhabiting the coastal water in the western Gulf of Thailand were ascertained from the analysis of the length-frequency distributions of fish in the commercial catches. The polymodal curve was dissected into component normal curves by the probability plot technique. At least seven batches of egg laying occurs each year. From these, however, apparently only two strong broods are produced. The

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1/ Two of Norman's (1935) nine species have been replaced with two other species by Anderson (1966a).

early group was produced in January, with .294 for K value per month and L_∞ about 19.96 cm. The late group was produced in July, with .345 for K value per month and L_∞ about 19.62 cm. The von Bertalanffy growth equation was fitted to the modal lengths of the size-frequency distributions during different months. The available tagging data of fish from the same region were used to ascertain the validity of the growth study. A close agreement in the results obtained independently by the two different methods indicated the reliability of the determination of age and growth.

No. 56 Significance of AOU of the Surface Water in the Kuroshio and the Oyashio Regions: A Slower Rate of Gas Exchange Between Air and Sea

by

Yoshio SUGIURA
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AOU is the difference between the saturation amount of oxygen and the observed concentration. The size of AOU has hitherto been considered only to depend on oxidative decomposition of organic materials and photosynthesis. But this study pointed out that a physical meaning existed besides decomposition and photosynthesis.

AOU of the surface water takes a positive and larger value at the end of the Kuroshio Current and on the other hand a negative and larger, absolute value at the end of the Oyashio Current. This indicates that the surface water is not in equilibrium with respect to atmospheric oxygen at the in situ water temperature and chlorinity; i.e., the rate of gas exchange between ocean and atmosphere is slower than the rate of heat exchange.

No. 57 Detection of the Erythrocyte Antigens of Tuna with Radioactive Antibodies

by

Akimi SUZUKI
Tokai Regional Fisheries Research Laboratory, Tokyo

An attempt was made to develop a blood typing method by using dried fish blood samples and radioactive antibodies. Rabbit immune antibodies, which were specific to the skipjack-K_1 antigen and the tuna-Tg2 antigen respectively, and natural antibodies specific to the carp-C antigens were purified by means of salting out and gel-filtration. These antibodies were iodinated and radioactive antibodies marked with ^{131}I were prepared. The nonspecific antibodies were eliminated by absorption using the usual method. Dried blood specimens were prepared by using sephad ex-G25 as an absorbent. The above-mentioned marked antibodies were added to the dried blood samples, and the excess antibodies were removed by centrifuging and filtration. Subsequently, the radioactivity of the residue was estimated by G-M counter. Data showed that the results obtained from radioactivity analysis agree very well with those from intact erythrocytes.

No. 58 Path and Transport of the Kuroshio South of Japan

by

Bruce A. TAFT
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Geomagnetic Electrokinetograph (GEK) and hydrographic data from quarterly surveys during 1956 and 1964 have been analyzed. Maximum current speed of the Kuroshio increases downstream from 132° to 137°E. Current speed decreases as the current goes from the deep water of the Sikoku Basin into the shallow water overlying the Izu Ridge. Mean volume transport relative to 800 db is 30 to 40% higher east of Cape Sionomisaki than to the west of the Cape. Most of the increase of the transport occurs between 136° and 137°E. The path of the Kuroshio in deep water appears to be more stable over a year's time than the path of the Gulf Stream after it has left Cape Hatteras.

No. 59 Notes on the Biology of Chub Mackerel (Rastrelliger brachysoma Bleeker) in Manila Bay

by

Elvira O. TAN
Philippine Fisheries Commission
Intramuros, Manila

Chub mackerel (Rastrelliger brachysoma) catches made by trawl and fish trap and landed at Navotas Fish Market, Manila Bay, have been sampled during the period 1964-66. Information is given on fish size, size at maturity, spawning season, and fecundity.

No. 60 On the Distribution of Copepods in Waters Surrounding Taiwan

by

Tien-hsi TAN
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Copepods from 43 stations in the waters surrounding Taiwan were collected in 1966. Investigations of species composition, abundance, and distribution of copepods as well as the oceanographic and physical conditions of the water, including temperature, dissolved oxygen, salinity, pH, and concentration of phosphate, nitrate, and silicate ions, have been made. The total number of species obtained in this area was 106, belonging to 23 families, 37 genera. The general distribution of copepods showed that stations within the Kuroshio were dominantly rich and those out of the Kuroshio were relatively poor. Comparison of faunistic relationships with the entire North Pacific area showed that the species here were very similar to those in the East China Sea and Pacific oceanic area, but quite different from those in the waters surrounding Japan and Korea. The species were divided into four groups, namely: cosmopolitan species, boreal species, temperate species, and tropic species. It was also found that species in each group occurred somewhat in a definite area.

No. 61 Synopsis of Biological Data on the Malayan Anchovy Stolephorus pseudoheterolobus Hardenberg 1933

by

Ah Kow THAM
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Data on the distribution, the various aspects of the bionomics and life history including nutrition, growth rate and behavior, the population characteristics including weight-length relationship and the exploitation of the species are summarized.

No. 62 A Study of the Plankton in Singapore Waters in Relation to the Environment

by

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The data on the monthly variations in the distribution of the plankton in three sectors of Singapore waters, viz: (a) Singapore Straits as observed by Tham Ah Kow, (b) Serangoon Harbor in Johore Straits as observed by Khoo Hong Woo, and (c) Ponggol Estuary, which drains into Johore Straits, as observed by Chua Thia Eng, including some more recent data collected by Tham and Chua, are presented and considered in some detail in relation to the data on the changes in the environmental conditions.

Certain plankters, such as the diatoms of the genus Coscinodiscus and copepods, are found in fairly large numbers in all three sectors throughout the year. However, certain phytoplankters, such as Thalassiothrix, Hemidiscus, Rhizosolenia, Biddulphia, Bacteriastrum, and Ditylum, whilst being always present in Singapore Straits throughout the year, only bloom during certain periods. They are usually not common in the other two sectors and bloom only very occasionally there. On the other hand, plankters such as Nitzschia, Lauderia, Guinardia, and Leptocylindricus are present in Johore Straits during the greater part of the year and bloom for short periods during certain months in the year, but are extremely rare in Singapore Straits.

Certain zooplankters such as the chaetognaths, siphonophores, decapod larvae, and Oikopleura are extremely rare in Johore Straits but are fairly common in Singapore Straits. On the other hand, planktonic organisms such as Ceratium, tintinnids, and bivalve larvae are fairly common in Johore Straits during the year, but are extremely rare in Singapore Straits.

A comparative study of the annual distribution pattern of each of the physical and chemical factors of the environment is carried out. There is a distinct correlation between the annual distributional patterns in the three sectors for each of the factors studied. This appears to be due to the interchange of water masses between Johore Straits and Singapore Straits twice a day as a result of tidal flow.

The relationship between the distributional pattern of the plankton and the environment is discussed.

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* Now carrying out research at the Institute of Fisheries, University of British Columbia.

No. 63 On the Changes in the Abundance of Demersal Fish Stocks in the Gulf of Thailand from 1963/1964 to 1966 as Consequence of the Trawl Fisheries Development *

by

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Ever since otter board trawl fishing was introduced into the Gulf of Thailand in 1960, the demersal fish catches have rapidly increased reaching a total landing of 337,000 tons in 1965. From 1963 on, systematic research has been conducted by the Demersal Fish Research Unit of the Department of Fisheries in cooperation with German Technical Assistance experts on the changes in the abundance of demersal fish stocks in the Gulf of Thailand. As it was not possible to build up reliable catch per unit of effort statistics for the commercial fisheries, it was decided to use the Department's own research vessel, Pramong 2, which was similar to a commercial trawler, in systematic surveys in order to obtain the desired catch per unit of effort data. Two complete surveys, extending along the whole coast of the Gulf of Thailand and down to a depth of about 50 m, have been made under exactly the same conditions, one in 1963-64 and the other during 1966. While the research results of the trawl surveys obtained during 1963-64 have already been published by S. Ruamragsa and A.P. Isarankura (1965) and also by K. Tiews (1965), this paper deals with the comparison of the results obtained in 1966 with those of the previous surveys. The changes in the total catch as well as the catch of fish used for human consumption and for industrial purposes are clearly illustrated.

No. 64 Plah-In-See (Scomberomorus spp.) of Thailand, 1967 **

by

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This qualitative document presents the biological, sociological, and economical knowledge of Scomberomorus spp. in the Gulf of Thailand, Indian Ocean, and adjacent waters that the author has collected during the past 2 years. It is based upon field reports, notes, and actual experiences during the period between October 1965 and October 1967. It is intended for use by the Department of Fisheries of Thailand and to inform cooperating agencies of the current situation of the Scomberomorus spp. fishery.

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** The journal in which this report is to be published is still under consideration, pending on the agreement between Thai and Malaysian authorities.

No. 65 On the Distribution of Plankton Settling Volumes in the Neighboring Seas of Taiwan, Summer 1965

by

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Honolulu

Plankton settling volumes were determined for the Kuroshio in the vicinity of Taiwan during 1965. The plankton samples were collected by 0-50 m, 0-100 m, 0-150 m, and 0-200 m vertical hauls with Norpac nets (mesh aperture 0.33 mm) equipped with flowmeter.

East of Taiwan, the plankton settling volumes were generally smaller than in the Taiwan Straits. During this warm season, the plankton settling volumes in the Kuroshio region east of Taiwan were higher in higher latitudes, where temperature and salinity were lower.

No. 66 A Preliminary Report on Cypridinids (Ostracoda) from Taiwan Straits

by

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The ostracod material from samples collected by the R/V Haehsien during a first survey of the grey mullet investigation in December 18-26, 1966 in Taiwan Straits has been examined. Six species belonging to four genera of the family Cypridinidae Baird have been identified. Horizontal and vertical distributions are discussed in relation to temperature and salinity.

No. 67 Studies on the Fishery Biology of the Grey Mullet (Mugil cephalus Linnaeus) in Taiwan

by

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This report summarizes the results of the studies of the fishery biology of grey mullet in Taiwan since 1958. The grey mullet can be distinguished from the other 10 species of the Mugilidae by its characteristic number (2) of the pyloric caeca. The grey mullet usually make their spawning migration to the middle and southern coast of Taiwan in the period from December to January.

The growth rate of male and female fish has been analyzed by age determination from scale readings and by the von Bertalanffy equation. All fish found in this area are mature individuals with well-developed gonads. Mean diameter of the egg has been found to be 0.62-0.68 mm. Fecundity is 700,000-3,000,000 eggs per female.

The migratory fish eat very little; mean stomach content has been found to be between 0.1 and 0.5 g, consisting mainly of benthos and copepods.

Good fishing condition seems to be associated with the approach of high atmospheric pressure, change of weather, neap tide, and a place where the coastline makes a turn. The optimal temperature for the migratory fish seems to be 21°-23°C.

The migratory grey mullet population consists of 2-8 year groups, the 4-year group being dominant. From 31 to 35% of the population has been found to be females. Survival rate(s) of the fish is 0.25.

From the available data, it is considered that the utilization of the grey mullet stock in Taiwan is near the maximum.

No. 68 The Skipjack Tuna Fishery in Palau

by

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Skipjack tuna (Katsuwonus pelamis) fishing in Palau has a history going back to the decade prior to the outbreak of World War II. From fishing bases established in Palau, Truk, Ponape, and Saipan in the former mandated islands, Japan carried on both longline fishing for large, subsurface tunas and billfishes, and pole-and-line fishing for surface schools of skipjack tuna. The Japanese stopped fishing these waters at the outbreak of war.

The present fishery for skipjack tuna is conducted by live-bait boats contracted to an American firm operating a freezer-storage plant in Palau. The boats are manned by Okinawan fishermen as well as Micronesian trainee-fishermen.

Historical data on catch and fishing effort and more recent data on skipjack tuna sizes and sexual maturity permit description of the fishery.

The principal baitfish is the anchovy, Stolephorus heterolobus, which are captured at night with the aid of a light to attract the fish. On the fishing grounds, schools are located by scouting for birds which are usually associated with the fish. Scouting is discontinued as darkness approaches and the vessels usually head for port to unload the day's catch.

In 1936, the Japanese had between 9 and 32 vessels fishing each month. Monthly catches ranged from 8.7 metric tons in February to 770.4 metric tons in December. The number of fishing trips ranged from 26 in February to as many as 612 in June. Catch per trip varied from 0.3 metric ton in February to 1.4 metric tons in November.

The average size of the skipjack tuna varied from month to month between 36 and 52 cm in 1936; in 1965-67, they ranged between 48 and 62 cm. For all years in which size data were examined, there was a pronounced tendency for the average size to increase in October-January. This increase in average size corresponds roughly to the increase in catch per trip in winter.

No. 69

Fishery Oceanographic Studies of Frontal Eddies and Transports Associated with the Kuroshio Current System Including "Subtropical Countercurrent"

by

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Through CSK cruises in the winter and summer of 1965-67 we have constructed synoptic maps of the salinity maximum and minimum, temperature minimum, oxygen maximum and minimum, surface salinity, transparency, etc., in the Kuroshio Current system and adjacent waters. Further using data in the maps published by the Japan Hydrographic Office, the distributions of the oceanic fronts and the computed vorticity and convergence were plotted. The meander of the Kuroshio and its associated highly productive zone are correlated to the vorticity zone.

The Kuroshio main stream circulates clockwise around the salty North Pacific Central Water, having salinity of about 35°/oo which is predominantly renewed in every winter by evaporation in the surface layer. The upwelling zones along or near the Kuroshio are located at the shallowest portions of the Intermediate Water (S-maximum). Dichothermal topography illustrates cold belts along the Kuroshio front aroused by cyclonic eddies.

We can note evidence of intense upwelling or upward flow along the shelf edge in the East China Sea on the inner side of the Kuroshio Current, suggesting strong mixing there.

Peculiar isolated warm and cold water masses along the Kuroshio front correspond to concentrated areas of albacore, mackerel, skipjack, Pacific saury, whales, etc. In general, oceanic fronts limit the distribution and migration route of commercial fishes and concentrate fishes and food organisms, particularly in these associated eddies.

We have found a new eastward current along the Subtropical Convergence in the North Pacific Ocean, "Subtropical Countercurrent"; geostrophic flow is present throughout the whole year and is particularly prevalent in winter and spring, showing a velocity of 0.2-1.3 knots and suggesting stronger subsidence of the salty central water along the Subtropical Convergence toward the core depths of the North Equatorial Current at the meridional sections. The location of the "Subtropical Countercurrent" lies nearly along the isotherms of 22°-23°C in the zone of lat. 20°-24°N at the depth of 100 m layer.

The width and thickness of the current are about 100 SM and 300 m, respectively. Its transport is of the order of 10% of the Kuroshio Current. The current shows conspicuous meandering, especially near the Palau-Kyushu Ridge and Izu-Ogasawara-Mariana Ridge as well as the western Kyushu-Ryukyu-Formosa Ridge, suggesting the migration routes of skipjack tuna. In the season from spring to summer a warm water intrusion occurs at the top of the meandering undulation, corresponding to the northward migration of skipjack. Conversely, in the period from autumn to winter a cold water intrusion develops along the ridges and the outbreak of the Subtropical Convergence occurs at the bottom of the meandering undulation, which may correspond to the returning migration route of the skipjack to the spawning grounds in the Mariana Sea and adjacent waters.

The warm and salty water intrusion from the South Pacific of the New Guinea Current northward into the Equatorial Countercurrent area in the northern summer might effect the population size of skipjack, yellowfin, and bigeye tunas inhabiting the North Pacific Equatorial Waters, in association with the equatorial upwelling in the areas of the Equatorial Countercurrent and the Equatorial Undercurrent in different ways.

Remarkable and persistent anticyclonic warm eddies exist in the south of Kushiro (Hokkaido) and east of Hachinoe (Aomori Prefecture), as favorable fishing areas of mackerel

in the summer and fall seasons along the Oyashio front (Subarctic Convergence or polar front). Also around them we can find very densely concentrated schools of Pacific saury, squid, and whales in early autumn at the top of the cold tongues of the Oyashio Current and its branches. Other persistent warm and cold eddies are found in the southeast or east of Kinkazan corresponding to favorable fishing localities of concentrated skipjack, mackerel, tunas, saury, and whales.

In cyclonic eddies along the marginal areas of the Kuroshio main stream we notice very good fishing localities of Pacific mackerel and jack mackerel in the East China Sea and south of Japan proper around the Izu Islands and reefs and on the Pacific side along the coast of Chiba Prefecture.

The water transport of the Kuroshio carrying fish larvae, eggs, and juveniles in tremendous quantities with some drifting seaweeds supports the recruitment of the important commercial fishes with great variability in accordance with the ever changing environmental conditions, especially of the oscillation of the current paths of the Kuroshio. Temporal variation of the current axis of the Kuroshio appears to depend on meteorological disturbances such as the passage of typhoons, cyclones, and fronts, and also on the degree of prevalence of the winter monsoon in oriental waters, which may affect the secular fluctuation of fish stocks, bluefin tuna, etc. Northward feeding migrations and southward feeding and spawning migrations of skipjack, mackerel, squid, Pacific saury, albacore, and so on, seem to be accelerated or retarded year by year subject to the changing paths and transports of the Kuroshio Current system. The timing of migration encountered in the favorable habitats might restrict the predominance of each fish species at their critical stages.

No. 70 Distribution and Relative Abundance of Larval Skipjack Tuna (Katsuwonus pelamis) in the Western Pacific Ocean

by

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Geographical and seasonal occurrences of larval skipjack tuna (Katsuwonus pelamis) are studied in the western North Pacific (west of long. 180°, north of the Equator).

South of lat. 20°N, skipjack tuna larvae are observed all the year round. In summer, although more abundant to the south, their occurrences extend widely to the north of lat. 20°N. Around lat. 22°N appears to be the northern limit of their distribution in winter, when they are most abundant in the equatorial region (lat. 10°N to the Equator). Larval abundance in the equatorial region increases to the west.

There is an indication that their larval occurrence varies appreciably year by year.

No. 71 Regional Distribution of Major Systematic Groups of Zooplankton in the Kuroshio Region Based on the Material Taken by Japanese Ships 1965-66

by

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The distribution and abundance of 24 groups of zooplankters taken by Japanese research ships in the CSK area are shown in a series of charts.

No. 72 Current Aspects of Geophysical Studies in the Kuroshio and Adjacent Seas

by

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Sadanori MURAUCHI, National Science Museum, Tokyo;
and Nozomu DEN, Hokkaido University, Hakodate

Results of geophysical studies in the Kuroshio and adjacent seas are reviewed. Heat-flow measurements show that the marginal seas, such as the Japan Sea and the Okhotsk Sea, are geothermally hot, while heat-flow in the seas east of Japan is uniformly subnormal. The geomagnetic anomaly lineations in the seas east of Japan, including the Okhotsk Sea, run in the ENE-WSW direction. The lineation trends in the Japan Sea are less distinct and run along the longitudinal axis of the sea. Seismic refraction measurements show that the crustal structures in the northwestern part of the Pacific Basin and the Philippine Basin are quite oceanic with the exception of the second layer with a little slower wave velocity. In the Japan Sea and the Okhotsk Sea, oceanic or suboceanic crust is found beneath the deep basins. The deep sea terrace is clearly found at the depths of 1,000-2,000 m on the continental slopes around the Japan arc. The rate of sedimentation varies from 0.05 to 1.5 cm/1,000 yr. in the seas east of Japan, while it is about 1.5 cm/1,000 yr. in the Japan Sea.

No. 73 The Variations of Oceanic Condition and Mean Sea Level in Korea Strait

by

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Variations of oceanic condition in the Korea Strait are studied in connection with the variations of mean sea level, using the oceanographic and tidal data from 1962 to 1967.

The variations of monthly mean sea level, reduced to standard atmospheric pressure, coincide well with those of steric sea level or dynamic height. The average current velocity or water volume transport through the Korea Strait in the western channel, computed by the geostrophic equation using serial oceanographical data, is well related to the difference in daily mean sea levels at both sides of the channel at Pusan and Tsushima, a distance of about 55 km.

The variation of difference in monthly departure of mean sea levels at these two stations indicates the annual variation of average surface current in the channel, which shows that the average northward surface current or Tsushima warm current in the channel has its maximum in October and minimum in March with an annual change of about 60 cm/sec or 1 knot.

The variation of difference in daily mean sea levels at these two stations from 1962 to 1966 suggests that the current in the channel varies remarkably, with periodicities of about 10-30 days up to 50 cm/sec during summer-autumn.

No. 74 Subtropical Countercurrents: Band Structures Revealed from CSK Data

by

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During recent years, there have been some observational indications that relatively well-defined eastward currents are present at latitudes between lat. 20° and 30°N in the North Pacific, where weak westward drift had generally been charted. A computation of transports from seasonal wind-stress distributions has shown that the eastward transport should exist at these lower subtropical latitudes, near the boundary between the westerly and trade wind zones (Yoshida et al., 1967).

To test this hypothetical explanation as well as the reality of existence of such curious features, some recent CSK data are examined extensively. Based on the data from winter-spring cruises, mostly from U.S.S.R. cruises, a remarkable and rather unexpected feature has been revealed. Geostrophic eastward currents do exist on nearly all sections between long. 127° and 155°E, particularly between lat. 21° and 22°N. A banded structure of the circulation and temperature distributions is clearly seen. Long-crested ridges in isotherms and isopycnals within thermocline layers are found with quite regular north-south intervals of some 300 km. Another set of data from the Trade Wind Zone Oceanography Pilot Study is also studied in relation to the western Subtropical Countercurrents. A theoretical interpretation is further attempted to account for all these observed pictures.

No. 75 The Effect of Environmental Factors on the Macro-Zooplankton Community Around Taiwan

by

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Macro-zooplankton samples were classified by analyzing the data from the third CSK cruise (September-October, 1966) and the fourth (April-May, 1967) into seven groups: large Copepoda, small Copepoda, Chaetognatha, Crustacea larvae, Medusa, Tunicata, and others. They are compared according to the number per unit of each group. In general, those in the main Kuroshio region (i.e., the eastern part off Taiwan) were less abundant than those in the northwestern part off Taiwan. As for the seasonal variation, in the main Kuroshio region, those of the fourth cruise (spring) seemed more abundant than those of the third (fall), and all the groups except Chaetognatha seemed to follow the same course; but in the northwestern region, those of the fourth cruise seemed less abundant than those of the third. In regard to production, the highest was in the northwestern region, while the lowest was in the main Kuroshio region. All of these phenomena can be explained in terms of the differences of the environmental factors.

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